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EDITORIAL NOTES.

THE RESPONSIBILITY OF THE LONDON COUNTY COUNCIL.

In our previous issue we dealt at some length with the question of the large number of existing buildings in the metropolis that do not comply with the requirements of the Building Acts (Amendment) Act of 1905 as far as safety from fire is concerned, and—as we anticipated—a vast amount of argument and correspondence—both confirmative and the reverse—has arisen from what we published. Not only have we been the recipients of numerous communications on the matter, but we see that both the daily and the technical Press in general have now accorded space to the subject editorially and by the insertion of letters, although none have perhaps "called a spade a spade" quite as plainly as we have. For the considerable amount of valuable support received from our contemporaries we would here immediately tender our best thanks.

Again, in the council chamber of the London County Council, of the Kensington Borough Council, and of other corporate bodies, the subject-matter of our editorial has been under comment. If we are rightly informed, there has even been a deputation on behalf of the shop assistants in the matter before the Building Act Committee at Spring Gardens. But for all this, there has been no definite public declaration on the County Council's behalf that the present lamentable state of affairs is to be remedied, and that the public is to be safeguarded in such a manner as was intended under the Building Act referred to.

It thus behoves us again to call the attention of the members of the London County Council and other authorities to the extraordinary scandal in our midst, for which, up to the present, the spokesmen of the London County Council have apparently been only anxious to find excuses, but have not promised prompt and effective remedy.

There is one point in particular that we must deal with next—we spoke of some 50,000 buildings awaiting attention, *i.e.*, buildings under the self-same Section 9 of the Building Acts (Amendment) Act of 1905, under which premises like those of Messrs. Barker come. We pointed out that not one thousand of these cases had, so far, been put in order in the intervening seven years. We gave the Council even greater credit than necessary—the exact number to June last was only 527. But, further, it would now appear, instead of our having to deal with 50,000, there are actually somewhere between 93,000 to 94,000

structures awaiting the Council's pleasure, for, in addition to those under Section 9, there is now official evidence available that no fewer than 48,566 cases have been duly notified to the London County Council under Sections 10 to 12, and that only 351 under Section 11, and 4,430 under Sections 10 and 12, have so far been put in order, or exempted from the operation of the Act. In other words, close on 44,000 cases are awaiting attention under the three further sections of the Act.

THE EXISTING POWERS.

To make ourselves quite clear, we would remind our readers that there is a Section 9 that affects buildings that are tall, or in which more than twenty people "live" or are employed. There is Section 10 that relates to projecting shops; a Section 11 that relates to certain dangerous stores; and a Section 12 affecting a number of minor structures. The buildings under Sections 9 and 10 are those most in the public eye. For those under Section 9 it required seven years to put 527 buildings in order, and under Sections 10 to 12 it has required seven years to put into proper order, or exempt, some 4,781 cases. We wonder if the public realises what this rate of progress means, for it would almost seem that *five centuries would be required to deal with the buildings under Section 9, and quite half a century to deal with those under other sections named.*

Now in a communication which we print in another column (page 64), the figures are not only summarised and confirmed, but the causes of the existing state of affairs indicated, and certain useful suggestions are made as to the remedy.

SOME SUGGESTIONS.

We offer no comment on the causes. They are public knowledge. As to the suggestions, we give them here *seriatim,* with an expression of opinion that they are feasible and economic, and would, if adopted, give us safer buildings without undue delay. They read as follows :—

(*a*) A public announcement in the Press (to be repeated monthly) that it intends to have the whole of the work under the Building Acts (Amendment) Act of 1905 remedied by January 1st, 1918, the public announcement to be followed by two circular notices in the 44,000 notified cases under Sections 10 to 12.

(*b*) An immediate instruction to the District Surveyors to notify to the Council, say within six months (as set out in Section 17) all cases they consider to come under Section 9—a matter that has been practically neglected during the past seven years—and immediately upon receipt of these notifications an issue of two circular notices to owners concerned that the Council are prepared to receive suggestions accompanied by plans with proposals as to convenient dates for carrying out the necessary structural improvements, and are prepared to assist in every possible way applicants who volunteer plans and offer practical remedies. The circular notices should indicate certain primary principles desired by the Council, such as alternative routes of exit from workshops and dormitories.

(*c*) A cancellation of the existing embargo that the fifty District Surveyors are not to press the execution of work under Sections 10 to 12 in their respective districts, and in place of that embargo an instruction that they shall see that the whole of this work is carried out by 1918 or earlier, the instruction to set out certain guiding principles as to remedies and also grounds for exemption. As to exemptions, any recommendation for exemption signed by the local District Surveyor and two adjoining District Surveyors should be accepted *ipso facto* by the Building Act Committee as a *prima facie* case for exemption without further investigation or expense.

(*d*) The energetic enforcement in 1913 by legal proceedings of at least one notoriously bad case under Section 9 and one under Section 10 in each district as an earnest of the Council's intentions.

(*e*) The formation of several Sub-Committees of three in the Building Act Committee to sit weekly to accelerate the decisions requiring the Committee's attention under the 1905 Act, with the necessary strengthening of the Superintending Architect's personal staff and the staff of the Committee Clerk.

(*f*) The immediate strengthening of the "Escape" branch in the Building Act Department by five managing assistants, twenty senior assistants, twenty junior assistants, and twenty clerks, etc., all on the temporary establishment, the staff to work by areas, and each senior assistant to follow his own case from beginning to end, all modern mechanical equipment and facilities to be used to accelerate the work, including photography and mechanical copying instead of tracing.

(*g*) The publication quarterly of a list of building owners who have complied with the Building Acts (Amendment) Act of 1905 and the addresses of the buildings that have been put in order.

In conclusion, we would only emphasise the necessity of prompt action on the Council's part. Otherwise the Council may unexpectedly find its functions largely superseded in this particular direction in a manner least expected. London cannot be allowed to stand as an instance of sluggish administration in matters of public safety, for it happens to be the Imperial capital of an Empire to which other municipalities should look up to, not the reverse.

"IRONMONGERS."

According to Webster's dictionary of the English language, an ironmonger is a "dealer in iron or hardware," and hardware is "the general name for all articles made of iron."

Under this definition several distinguished presiding officers of corporations, such as the Institution of Civil Engineers, or the Iron and Steel Institute, would from time to time certainly come. Yet, if their vocation were so described by their fellow officers, or by any individual member of these institutions, they would no doubt resent it as something derogatory, no matter how estimable ironmongers as a class may be.

At the Concrete Institute, at two of its recent meetings, the term "ironmonger" was bandied about in this derogatory sense, with a view to describing concrete specialists generally, and particularly such specialists who sell reinforcing bars and other accessories for the construction of reinforced concrete buildings. Now, if the proceedings of the Concrete Institute were private, there is no reason why individual members of council should not give full expression to their views; but the proceedings being public, such views and classifications do not add either to the dignity of the institution concerned, nor do they assist in furthering the subjects there under review or advance the status of those concerned, be they members of the technical professions in the highest sense, captains of industry, or the lesser lights of the commercial firmament.

The Concrete Institute is wisely constituted of professional men in the highest sense, professional men connected with the industries concerned, and others engaged in the execution of contracts for the erection of structures, or the purveying of materials necessary thereto. It is only by active, cordial co-operation between the different elements concerned that an advance is likely to

be made, either in the scientific investigation or practical application of concrete or reinforced concrete, a subject essentially dependent on the results of science-*cum*-industry. The Institute was formed solely by the co-operation of these two elements, for those concerned purely in the industrial side are far too jealous of one another to allow of their cohesion as a separate entity, and even if such a cohesion were possible, their views would have as little weight with the world at large as that of any of the other very estimable, but purely *ex parte*, industrial associations.

Again, the professional and scientific side of the Institute's work would lose immeasurably by the absence of co-operation from the commercial element which includes men of considerable technical eminence and experience.

For either element to commence to wrangle with the other, because there happen to be a few black sheep, is regrettable—the black sheep, it should be added, being common to both elements—and the sooner unseemly differences of this description are relegated to oblivion the better for the advancement of concrete and reinforced concrete and the progress of the Concrete Institute in particular.

H.M. NEW STATIONERY OFFICE.

The new Stationery Office for H.M. Office of Works will, when completed, rank among the largest reinforced concrete structures erected in England. There are many points of special interest in this building, and not least among them the steel gantry employed in its construction. We hope at a later period to supplement the present article by a further one dealing with the structure when it is more advanced. This article has been prepared for us by Mr. Albert Lakeman, Hon. Medallist Construction.—ED.

THIS new building is highly important from a constructional point of view, as the methods employed are quite unique, as will be seen from the accompanying photographic views. The fact that reinforced concrete is adopted by the Government for a structure of this magnitude is evidence of the almost universal opinion that it is by far the most suitable material where fire-resistance, economy, and rapid erection are the primary considerations.

The whole scheme consists practically of two blocks, the smaller of which is to be used as offices and the larger as a warehouse, a portion of which will be devoted to H.M. Office of Works. Some idea of the magnitude of the building, which has been designed by Mr. R. J. Allison, A.R.I.B.A., Architect, H.M. Office of Works, can be gathered from the general dimensions, which are as follows:—Frontage to Stamford Street, 323 ft., to Cornwall Road 189 ft., to Doon Street 377 ft., and to Waterloo Road 106 ft. The site is practically an island one, with the exception that a large portion at the south-west corner is occupied by the Royal Waterloo Hospital for Women and Children, and a small street called Bazon Street cuts between the office and warehouse blocks and gives access to the back entrance of the hospital. The two blocks will be connected, however, by a bridge which is 40 ft. wide, and constitutes practically a building above the first-floor level. The average height of the main front walls above the pavement level will be 77 ft., and there are seven floors in the warehouse portion and eight floors in the office block, including the sub-ground and basement, the height generally from floor to floor being 10 ft. 6 in. in the former and 11 ft. in the latter. The present contract provides for a floor area of about 380,000 superficial feet, but an extension has been arranged for consisting of a fifth floor and the covering of one corner of the site adjacent to Doon Street and Cornwall Road, which will provide a further 100,000 superficial feet, or a total of roughly eleven acres for the complete scheme. The general disposition of the ground floor is shown on the plan illustrated in *Fig.* 1, where the complete scheme is given. It will be seen that three large internal areas are provided in the warehouse for lighting purposes, and there are two in the office block. A covered loading yard and platform is provided adjacent to Doon Street, and the goods will be handled here and despatched to the various parts of the buildings by means of

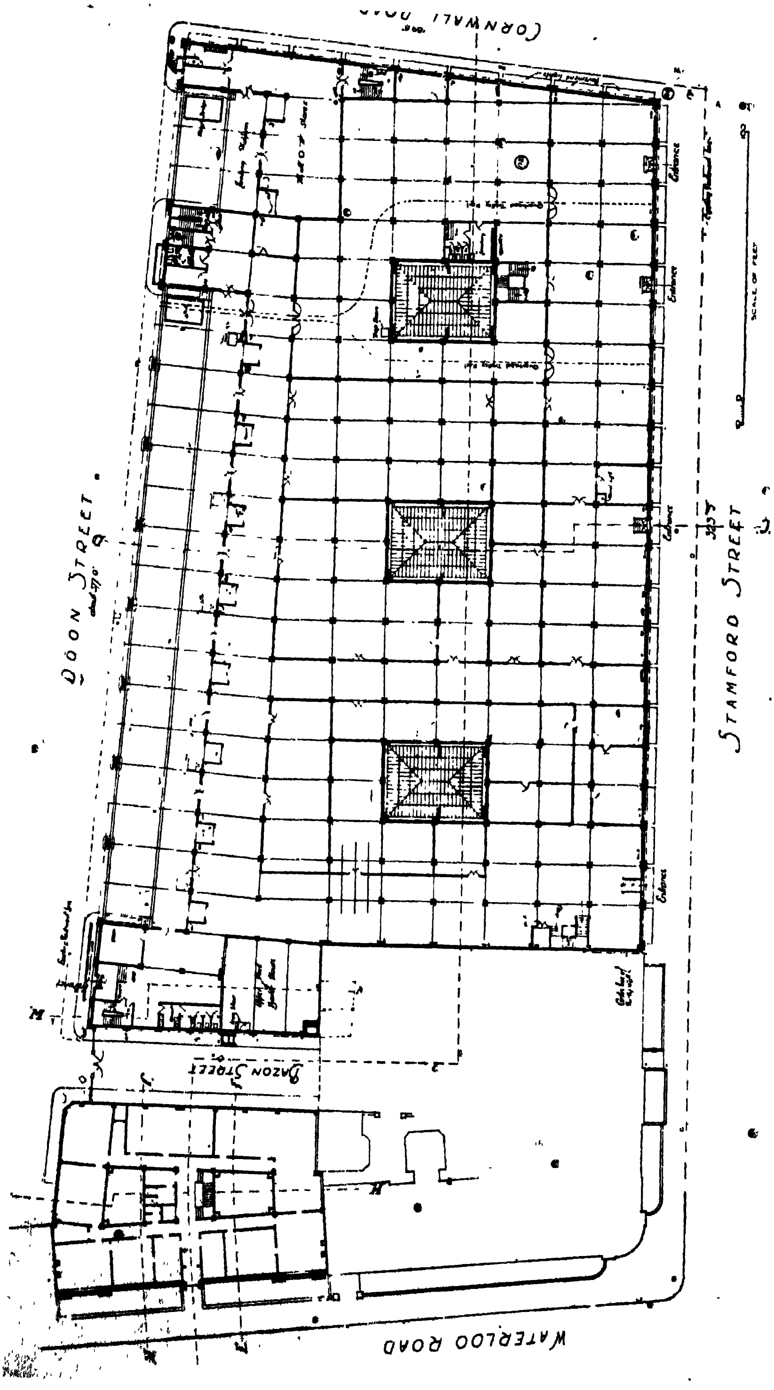


Fig. 1. Ground Floor Plan.
H.M. NEW STATIONERY OFFICE.

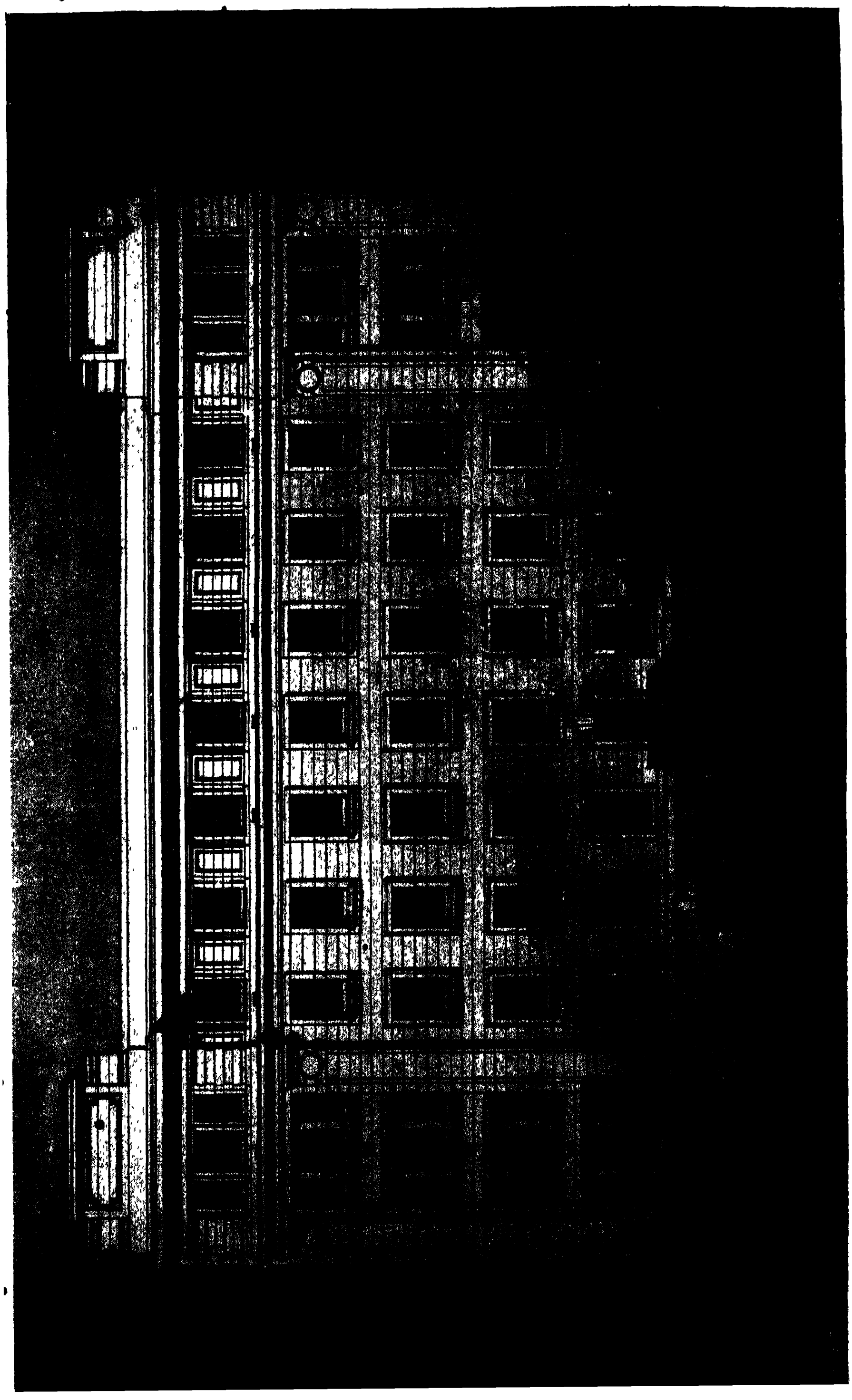


Fig. 2. Elevation to Waterloo Road.
H.M. New Stationery Office.

eight electric lifts, which are situated at the back of the platform. A smaller loading yard and platform will be provided at the N.E. angle of the site. This end of the building will be arranged for use by H.M. Office of Works Stores Dept., and two additional lifts will be provided. In addition to these ten lifts

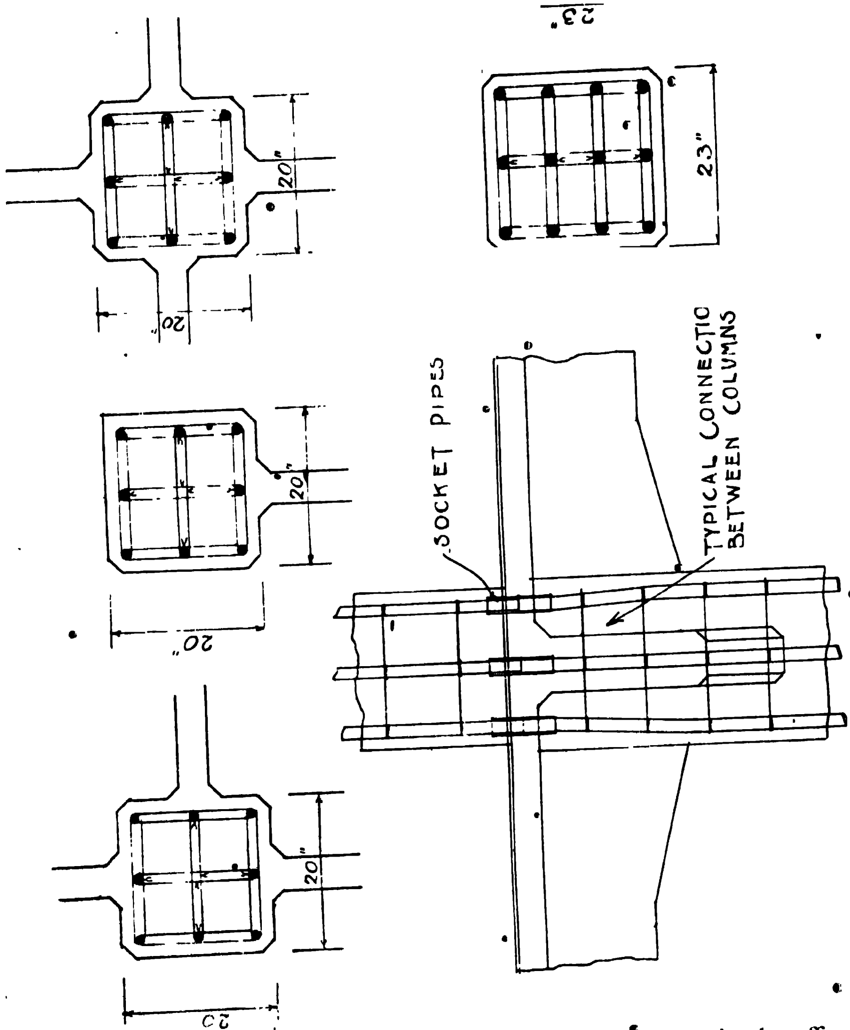


Fig. 3. Column Details.
H M. New Stationery Office.

there are two for passengers—one in the warehouse and one in the office block—and also a goods lift in the latter to supply the top floor, where a large dining-room and kitchen are provided for the accommodation of the staff. The whole building will be heated by hot water under forced circulation, and the drainage will be carried by cast-iron pipes laid under the basement floor.

In the execution of the work a unique feature is provided by the use of steel gantries, which are shown in the photographic views; and, although these are used in modern shipbuilding, it is safe to say that this is the first

instance in which they have been used in building work. These gantries have, in fact, been modelled on the lines of those used in shipyards, and it is believed that they will effect economy in time and expenditure as compared with the usual type of derrick crane. It will be interesting as an experiment to see how far the hopes of the designers are realised, and it will certainly be found extremely convenient to have the whole site practically unobstructed and available for working at all times.

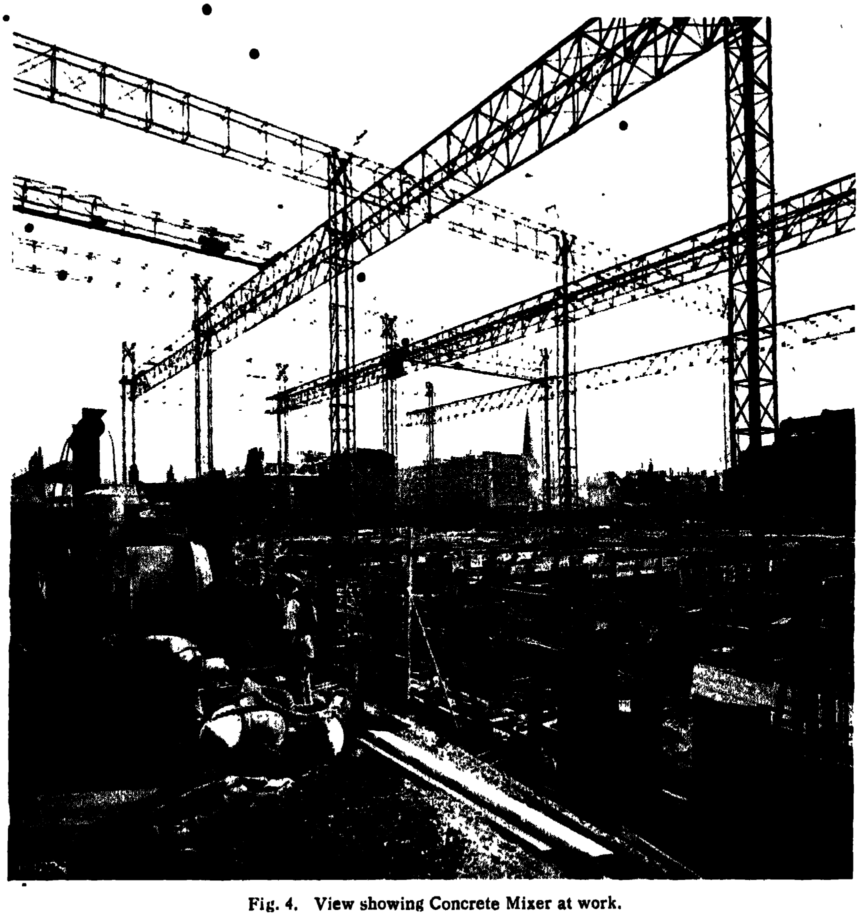


Fig. 4. View showing Concrete Mixer at work.
H.M. New Stationery Office.

The vertical lattice members of the gantry are placed in three rows at distances apart of 81 ft., 66 ft., and 66 ft., and the cross girders are built up of steel sections in open lattice type, used in pairs, well braced across the top and stiffened by diagonal struts between each pair to give strong and light design. Electrically-driven travellers run over and serve the whole area, and they are each capable of hoisting or lowering, and of travelling in transverse or longitudinal directions. They can handle 300 cubic yards per day, and are capable of lifting the full load of 30 cwts.; and while carrying this load

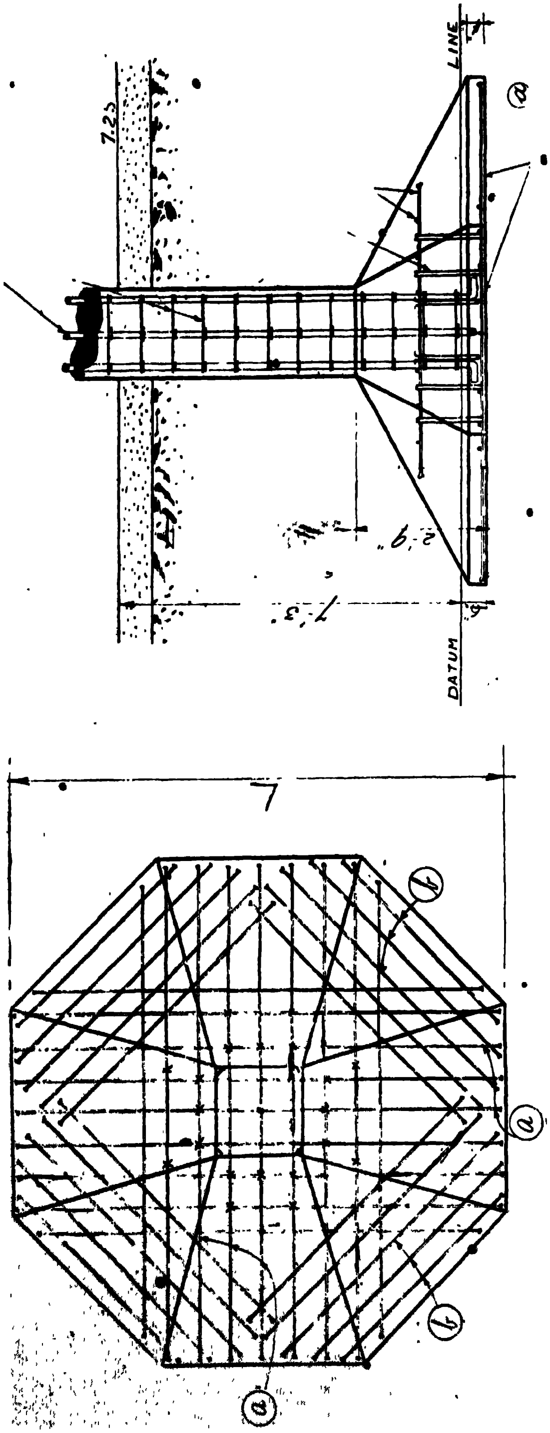


Fig. 5. Typical Column and Foundation Slab.
H.M. New Stationery Office.

can lift at 150 ft. per minute and travel crossways at 150 ft. per minute, or longitudinally at 480 ft. per minute. A powerful automatic brake is provided, capable of sustaining the load, and arranged for lowering by gravity; and there is a foot-lever brake for controlling the longitudinal movement of the crane. A platform with hand-railing is provided alongside one of the cross girders, and the controllers are placed in a cage fixed underneath the cross girders. The erection gantries were put up by means of small derrick cranes, which travelled in trenches, the upright and longitudinal members being erected in the first instance, and the end girders being then pulled up by little cranes at the top, which will remain in position and be utilised in the taking down; the girders being removed in the first instance and the uprights being taken down in sections.

The building itsel is being erected on the Hennebique system, designed by Messrs. L. G. Mouchel and Partners, Ltd., and the whole of the concrete is being machine-mixed with three Ransome patent

concrete mixers, one of which is illustrated in *Fig.* 4. The soil was found to be composed of 10 ft. of made earth with about 16 ft. of gravel underneath resting on blue clay, and the whole of the foundations are taken down well into the gravel soil and designed to give a maximum pressure of 3 tons per square foot. The bases to the columns are carried down generally to a depth of about 8 ft. below the basement floor level, and these are octagonal on plan, as illustrated on *Fig.* 5. This is a most economical form and it has a maximum thickness of 2 ft. 9 in. adjacent to the column, splayed down to 4 in. at the extreme outer edges in the particular example illustrated, while the greatest width shown at L in the diagram is about 10 ft. The disposition of the reinforcement is sufficiently clearly shown to need no detailed explanation, as is also the method of taking the vertical lines of reinforcement into the foundation slab. Very few of the foundation slabs were square, and in all such cases the loads were comparatively small.

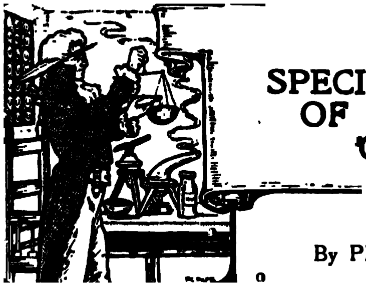
The retaining walls, generally speaking, are formed with 6-in. slabs, stiffened by horizontal beams at the top and bottom and with counterforte about 7 ft. apart, while short cross walls are carried back to the columns supporting the outside walls, which are spaced at intervals of about 20 ft. The height of the walls vary considerably owing to the different level of the roads, but the same principle of construction is employed throughout. The columns are spaced generally in rows 20 ft. apart at intervals of 15 ft. 2 in., and some typical details are illustrated in *Fig.* 3, where it will be seen that the size of the ground floor varied from 20 in. square to 23 in. square, with eight to twelve lines of vertical reinforcement well tied with links, 10 in. apart, in all directions. A typical connection between the columns is also given showing how the bars are connected with socket pipes.

One rather important point in connection with the construction is that dealing with the proportions employed for the concrete. This is somewhat different from the usual mixture, it being composed of one part of Portland cement, one part of sand, and two parts of ballast for columns. The remainder is as follows: 1 cwt. cement, 2 cubic ft. sand, 4 cubic ft. ballast. It will be seen that the mixture for columns is much richer than that generally used, and in consequence a greater stress is allowed on the concrete per square inch, and a smaller quantity is used in consequence. It is claimed that economy is effected in this way, as the reduction in the quantity of concrete obviously reduces the loads to be carried and thus the sizes of the members are reduced throughout. The floor loads have been calculated at 3 cwts. per sq. ft. for the ground floor of the warehouse and 2½ cwts. for the upper floors, while in the offices the allowance is 100 lb. per sq. ft. for all floors and 65 lb. for the roofs. These loads are in addition to the weight of the floor itself, and the slabs are only 3½ in. thick in the warehouse and 3 in. thick in the offices. These floor slabs are carried by secondary beams, which are in turn carried by main beams; and the whole of the skeleton reinforcement, wherever possible, is built up completely before being placed in the moulds, as this is considered to be cheaper than building up in the moulds and, furthermore, ensures more accuracy in the placing of the rods. The external walls generally are 4 in. and 6 in. thick, and the front

of the office block facing Waterloo Road will be faced with Portland stone, carried by the reinforced concrete columns and beams mainly at the level of the sub-ground floor. The chimney from the boiler-house is being formed in reinforced concrete, and this is 110 feet in height, with an inside size of 4 ft. 3 in. square, the sides being 7 in. thick at the bottom and 5 in. thick at the top. A fire-brick lining will be built in sections inside the shaft and supported by corbelling, this being kept 3 in. clear from the concrete sides. It is estimated that over 1,200 tons of steel will be required for the complete building, and as all

Fig. 6. View showing Reinforced Concrete Work.
H.M. New Stationery Office.

this is in the form of small round rods, it represents a very large amount. The work is being executed by Messrs. Perry & Co., Ltd., of Bow, while the steelwork for the gantry was supplied and erected by Messrs. Drew-Bear, Perks & Co., Ltd., Battersea Street Works. The reinforcing steel is being supplied by Messrs. Dorman & Long, of Middlesbrough, and the ballast is being procured from the Ham River Grit Co., Rochester.



THE SPECIFIC GRAVITY OF PORTLAND CEMENT.

By PERCY C. H. WEST.

The following article may be of interest as indicative of some of the more recent work which has been done in this particular branch of research.—ED.

So much has already been written relative to the specific gravity of Portland cement, that a certain hesitancy is felt in reverting to the subject. Much work has recently been done which is of merely confirmatory nature, and older and often more complete work has been overlooked; the results obtained by the several investigators have not been compared nor received adequate attention, with the natural result that in many quarters great importance is attached to the test, although the results of systematic research show that it is of extremely limited value.

Nearly thirty years ago sufficient evidence had been collected to show that the test as an indication of the quality of cement was of little use; in fact, could be well dispensed with. Yet to-day, as every manufacturer knows, there are many users of Portland cement who regard the test as of the greatest value, and who will disregard the more practical indications of high quality, such as mechanical tests and soundness tests, if the specific gravity falls below some arbitrary limit. The volume weight test to which the determination of specific gravity may be regarded as the natural successor has fallen—quite rightly—into desuetude. It was early recognised, notably by Grant, that the weight per bushel was a function of the state of division and the specific gravity, the method of carrying out the test remaining the same.

As is generally known, the test was held to be of use in differentiating between cements which had been burned at a high temperature or clinkered and those burned at a lower temperature, as, for example, Roman cement. It will usually be found that Roman, or natural cement, which has not been clinkered has a lower specific gravity than Portland cement, but the mechanical strength tests will equally well enable the two classes to be differentiated. When the test is applied to Portland cement, with the object of ascertaining its quality or the degree of clinkering, the results are much less positive.

Michaelis, in the earliest standard text-book on the subject, gives the specific gravity of Portland cement as 3·2, and states that the specific gravity of light burnt cement is not more than 0·1 lower and of overburnt 0·3 below this figure.

Seger and Aron determined the specific gravity of a number of samples of Portland cement, and found that they gave figures varying between 2·99

and 3·08. Schumann (1883) determined the specific gravity of twenty samples, and found that, as a rule, they fell between 3·110 and 3·174; in one case he found over 3·23, but never obtained a figure below 3·1. These results indicate a considerable variation. The cause of this variation was only imperfectly known at the time. Erdmenger found that the specific gravity of a clinker was dependent on the temperature at which it was calcined. He found that, not only did underburnt cement have a low specific gravity, but clinker produced at a high temperature also gave a low figure. This fall in specific gravity is shown to occur as a result of burning at a very high temperature by the results of Fresenius, published in 1885. In this case the amount of carbon dioxide and of water present in the clinker was also determined. Vicat, in his book, "Cimente et Chaux Hydrauliques" (1891), states that the specific gravity indicates adulteration and degree of burning. In the figures given by him as an example, the same fall of specific gravity, as the result of clinkering at a high temperature, is indicated.

Meyer, at a later date—1897—obtained precisely similar results, employing a mixture which, when burnt, had the following composition:—

Composition;	$CaO+MgO$	CaO	$SiO_2\ R_2O_3$			
	66·6	64·25	32·4			
Cone ...	7	8	10	12	14	16
S.G. ...	3·155	3·224	3·212	3·198	3·185	3·170

These figures are of great interest, as they show the relation between the specific gravity and the temperature of burning the clinker with a greater degree of precision. As late as 1907 we find results of a somewhat similar character being published by Meade and Hawke.

In view of the requirements of the specification of the Association of American Portland Cement Manufacturers, these chemists considered it necessary to emphasise the slight difference in specific gravity between imperfectly burnt and well-burnt clinker. They give examples showing that in a certain case the difference was only 0·026:—

1. Very light burnt	3·208
2. Somewhat lightly burnt	3·222
3. Well burnt	3·214
4. Very hard burnt	3·234

In this case the clinkers were all produced from the same batch of raw material, and were produced in the same rotary kiln. They further state that in no case have they found half-burnt giving a lower specific gravity than 3·10.

Butler (1906) found that, of thirteen samples of underburnt, eight possessed a sufficiently high specific gravity to satisfy the requirements of the B.S.S.

Within the writer's experience the lowest specific gravity of a thoroughly clinkered mixture was 3·024. This clinker had an abnormal composition, containing only 50 per cent. of lime, and naturally disintegrated on cooling. With a normal composition the specific gravity of clinker produced from the same materials did not fall below 3·17.

From these results it follows that the specific gravity of a thoroughly well-burnt clinker varies between wide limits; that under certain conditions a large

proportion of material of lower specific gravity could be added without causing the resultant mixture to have a specific gravity less than many undoubtedly pure clinkers possess.

Unreliable, however, as is the specific gravity test when employed for estimating the degree of burning or the purity of ground clinker, it is much more so as applied to finished cement.

It is permissible to add a certain percentage of gypsum, a material having a specific gravity of 2·3 – 2·9. Fuel dust may be present in a cement, whereas in testing clinker its presence may be avoided. Water and carbon dioxide are absorbed by the cement during the grinding process, and in storing either, or both, may be intentionally introduced into the cement. Thus there are three additional factors which have an effect on the specific gravity of the cement. The first two may be neglected, as they are present in only small percentages, and their effect is therefore small. The latter, however, is of considerable effect, a fact observed at a very early date by Erdmenger, who found that a cement having a specific gravity of 3·2 on storing five months absorbed 1·8 per cent. of water and CO_2; the specific gravity falling to 3·00. After storing eight months 2·2 per cent. had been absorbed and the specific gravity fell to 2·96. In another case quoted by him a cement having originally a specific gravity of 3·09 after one year had absorbed 2·1 per cent. and its specific gravity had fallen to 2·85.

Schott (1885), recognising the cause of the decrease in specific gravity, suggested a method of calculating the specific gravity of the clinker from that of the cement. He found that a sample giving a loss on ignition of 3 per cent. had a specific gravity of 3·094. Assuming the specific gravity of the clinker to be 3·15, he calculates the specific gravity, if all the loss on ignition be due to water, as follows :—

Specific Gravity of Water 1·0

$$\frac{97+3{\cdot}15+3{\cdot}00+1{\cdot}00}{100}=3{\cdot}085.$$

If loss on ignition is due to CO_2 : $6{\cdot}8CaCO_3$ of $S.G.$ 2·7

$$\frac{93{\cdot}2+3{\cdot}15+6{\cdot}8+2{\cdot}7}{100}=3{\cdot}11$$

Assuming the cement to contain equal proportions of water and carbonic anhydride, we get the following $S.G.$:—

$$\frac{3{\cdot}085+3{\cdot}11}{2}=3{\cdot}09$$

Schott's equation may be put in the following form :—

$$\therefore x=\frac{100y\ (n\ 1)-(m\ 1{\cdot}82)}{97}$$

where x is the specific gravity of the clinker; y the specific gravity of the cement; n = percentage of water; m = percentage of CO_2.

Hauenschild has suggested a purely empirical formula:

$$Sb=Sa+\frac{Sa.b}{100}$$

In which $Sb = S.G.$ clinker.
$Sa = S.G.$ unignited cement.
b = loss on ignition.

And F. M. Meyer has suggested $Sb = Sa + 0{\cdot}035b$.

These two formulæ have been checked by Gary (1905) against actual determinations. As might be anticipated, the results are by no means concordant. It may be noted that the nineteen cements tested by Gary gave an average difference of 0·0445 per 1·0 per cent. loss on ignition.

Butler has developed a formula enabling the specific of the clinker to be calculated from the specific gravity of the cement, and the percentage of water and carbon dioxide present in it being known. The calculation is, however, a somewhat lengthy process, and as the determination of the relative amounts of carbon dioxide and of water are necessitated, it is of little value. Another writer has suggested the calculation of the specific gravity of the clinker in a similar manner and has fallen into the error of taking the specific gravity of a compound to be the mean of the specific gravities of its constituents. That it cannot be done in the case of a lime-water reaction is apparent from the swelling up of lime on hydration and also from determinations of the specific gravity of calcium oxide and of the hydroxide.

It has been shown by Brugelman, Moissan, Richter, and others that lime can be obtained having a specific gravity as low as 3·08, or as high as 3·4, depending on the temperature at which it is burnt. The hydroxide in the amorphous form has a specific gravity of 2·078 (Rose) and crystallised in the hexagonal form 2·239 – 2·241. If the specific gravity agreed with the simple rule of averages and the specific gravity of calcium oxide was 3·0, then that of the hydroxide would be 2·3, and if the oxide was 3·2 then that of the hydroxide would be 2·66.

As the specific gravity of clinker varies between such wide limits, and as the specific gravity of calcium hydroxide in its several forms is also variable, it is of little use calculating the fall in the specific gravity of clinker due to the absorption of carbon dioxide and of water. The following figures, however, indicate the possible effect:—

Clinker $S.G.$	$S.G.$ $CaCO_3$ or $Ca(OH)_2$ assumed	Reduction of $S.G.$ by 1% H_2O
3·18	2·24	0·033
3·18	2·08	0·047
3·18 ($CaCO_3$)	2·7	0·013 by 1% CO_2

Of less moment in this connection is the addition of gypsum, the specific gravity of which, as $CaSO_4\,2H_2O$, is 2·306 Dumas, 2·331 Filhol. In the anhydrous form it has a specific gravity of 2.97 Schrauf.

Calculations, therefore, are of little value, as these results are mere approximations at best. The apparent alternative of driving off the moisture and carbon dioxide leads to little better results, but in view of its relative simplicity it is to be preferred to the other method. It has been well pointed out by Kupffender that by heating the cement to 110° – 120° only hygroscopic moisture is driven off. At higher temperatures first the combined water from the gypsum, then

from the calcium hydroxide, and finally the CO_2 from the carbonates is expelled. Even then the mass does not necessarily give the specific gravity of the clinker; for, as previously mentioned, the specific gravity of lime increases by heating. Only if the cement is heated to the original clinkering temperature would an approximately correct result be reached. And, if the heating was carried to this degree, 1400° – 1500° C., any badly burned or unburned material would be converted into material of high specific gravity.

The determination of the specific gravity on cement as delivered is of no practical value, for if it is desired to discover whether the cement has been stored carelessly or too long, a determination of the loss of ignition will show it directly, and with a greater degree of accuracy. With regard to this point, too, an odd one or two per cent. is of little consequence if the mechanical tests prove that the cement has ample strength. Determination of the specific gravity on the cement heated to redness gives more information than the test carried out on the unignited cement and may serve to indicate gross adulteration, that is if the lost free cement has a specific gravity less than 3·1.

Nothing has yet been said with regard to the accuracy with which determinations of specific gravity are made. Differences between authorities is fairly common, but the following is an illuminating instance. Dr. Heiser took 25 samples of cement, tested them himself, and had them tested at Gross Lichterfeld and at Malines (Belgian State Laboratory), with the following average results :—

Gross Lichterfeld.	Malines.	Dr. Heiser.
3·150	3·118	3·127

The greatest difference was 0·076, while the average was 0·032.

In conclusion, the words of Zwick (1879) may be well repeated : " It therefore follows that the specific gravity is a doubtful criterion of the value of cement."

RECENT REINFORCED CONCRETE CONSTRUCTION IN ALEXANDRIA.

By T. D. KEY
(Alexandria Water Co., Ltd.)

A considerable amount of very interesting reinforced concrete work has recently been carried out in Alexandria, and the following article deals with a few of these structures.—ED.

To the well-informed mind the word Egypt generally conveys an impression of the Arabian Nights and romantic associations of a desert life, and the visitor in quest of such usually obtains something very much in the nature of a shock when his port of debarkation on Egyptian soil happens to be Alexandria.

It would, indeed, be hard to find a greater contrast between the ideals of the first and the realities of the second than are presented by the town of Alexandria of to-day, and the tourist, realising this at sight, soon shakes the dust off his feet and departs for the more congenial delights of Cairo, Luxor, or Assouan.

Yet to the observant mind Alexandria presents many features of interest, its commercial and industrial activity, together with a magnificent harbour, having made it again one of the foremost cities of the East, and in the process the enterprise of its citizens has neglected few of the advances in science and engineering which have helped to promote the success of its Western rivals.

As the title of this article suggests, its object is to confine itself to giving a brief outline of the work done in Alexandria in those most recent methods of constructional engineering, reinforced concrete. And I think I am correct in stating that the first reinforced concrete work of any magnitude carried out in that town was in 1905, when, during the reconstruction of the Water Works, the new clear water storage reservoirs were roofed over with this material. Constructionally these roofs present no features worth recording. One point, however, which may interest your readers is the fact that, owing to a shortage of material, a considerable part of one of the roofs was made with concrete having as an aggregate ordinary furnace ash drawn from the Water Works boiler furnaces. About two years ago I had occasion to cut through the whole length of that part of the roof so constructed, and no evidence of corrosion was noticeable on any part of the reinforcement.

Since that date the Water Works have carried out two important structures in this material, the first, in 1909, a culvert connecting the company's private canal with the suction wells situated outside the main pumping house, its object being to supplement an existing culvert in brickwork, built about forty years ago, and of whose safety the Water Works authorities had grave doubts. Before work was commenced on the culvert a new intake house was

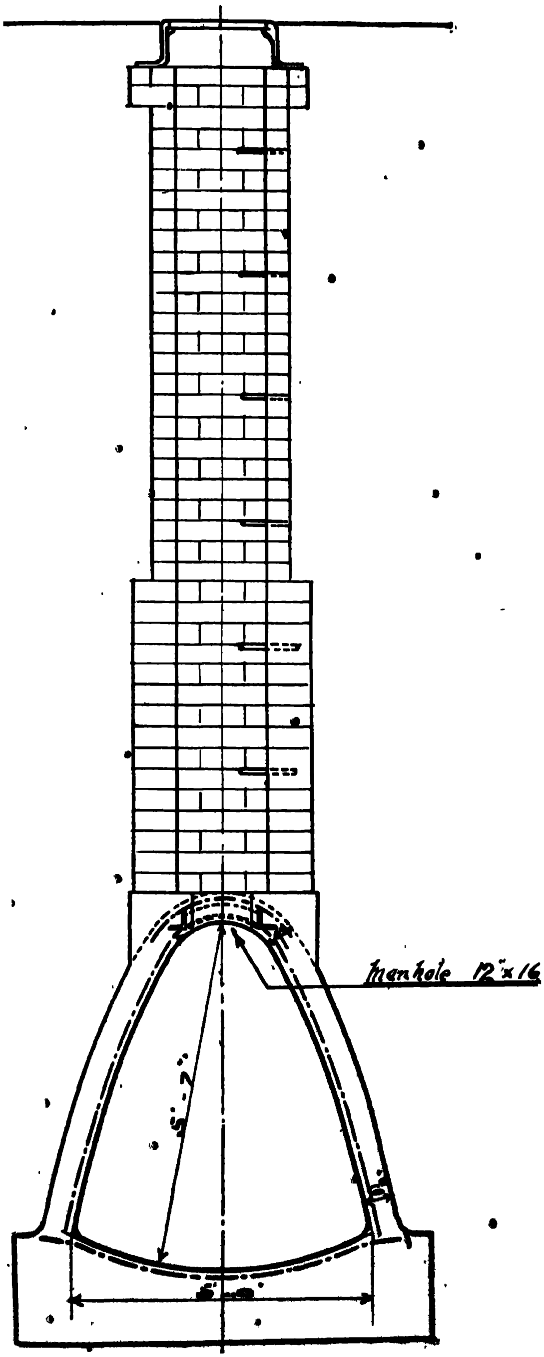


Fig. 1. Section.
REINFORCED CONCRETE CULVERT.

built at the canal end, and to this both old and new culverts were finally connected. The control penstocks and screens were also placed in this house.

The new culvert was made entirely of reinforced concrete and has a section as shown in *Fig.* 1, this section being determined on the assumption that it would be necessary to supply 13·2 million gallons (60,000 cubic metres) to the pumps in 12 hours when the water level in the canal was at a minimum of 3 ft. above the culvert invert.

The reinforcing throughout was done by means of expanded metal, No. 10 size, having strands of 3-in. mesh, the section of the strand being $\frac{3}{16}$ in. by $\frac{1}{8}$ in., the metal being laid the long way of the mesh at right angles to the axis of the culvert. The wooden centering used is well shown in the illustration, *Fig.* 2, and was made in lengths of 4 metres, each length being collapsible and easily removed after the concrete had set. This centering was covered at each stage with oiled paper, thus protecting the centering from deterioration through contact with the concrete, and also to provide a smooth inner surface to the culvert. So satisfactory were the results in this latter respect that in only a few places was it necessary to add any cement rendering to the inner surface of the finished work. The following mixture was used in making the concrete: 1 part of Portland cement to 3 parts of sand, 2 parts of this mortar to 3 parts of an aggregate composed of broken pottery thoroughly washed and screened through a 2-in. ring, all parts being measured by volume. Regarding the aggregate, a word

of explanation may not be amiss. This is broken Egyptian pottery, known locally by the name "chakf," and immense quantities of this material are to be found all over Egypt buried under small hills, or "koms." Being strong under compression, and having sharp edges, it makes a good aggregate for concrete when care is taken to use sufficient cement and sand to fill all the interstices. A disadvantage to its use in reinforced concrete, however, is that it cannot be conveniently broken to a small size. This fact, together with the increased cost due to the available supplies around Alexandria being nearly exhausted, has practically stopped its use for this purpose. The concrete was mixed wet and well tamped into place, the outside shuttering

Fig. 2. Wooden Centering.
REINFORCED CONCRETE CULVERT.

being placed in position in narrow strips to enable this to be conveniently done.

The culvert is provided with manholes about 262 ft. apart, these manholes being formed in the crown of the arch, which is strengthened at these points by means of an angle iron saddle cast into the concrete. The depth of the crown of the arch below the surface level varies from 12 ft. at the canal end to 24 ft. at the suction wells. At the deeper levels reinforcement was placed on the outer side of the crown in order to provide against the increased horizontal thrust. The total length of the culvert is about 1,670 ft.

The second is a settling basin, forming one of a group of four, and used for precipitating, under the action of alumina sulphate, the fine Nile mud held in suspension in the water before this is treated by the filters.

Its construction is well shown in the drawing, *Fig.* 3, and its action as an

efficient precipitating tank may be briefly described thus: The unfiltered water is pumped into the semi-circular basin, A, from which it flows with a greatly diminished velocity towards the diaphragm wall at B. This diaphragm is composed of two parallel walls, that nearest the inlet acting as a weir, the other as a baffle with openings at its lower base through which the water passes to the outlet overflow weir at C. These two weirs have the effect of skimming off the surface and clearer water in each compartment of the tank, and retain the greater quantity of silt left in suspension in the lower water levels. The working capacity of the tank is one million gallons, and the time allowed for this quantity to flow through is regulated to about six hours.

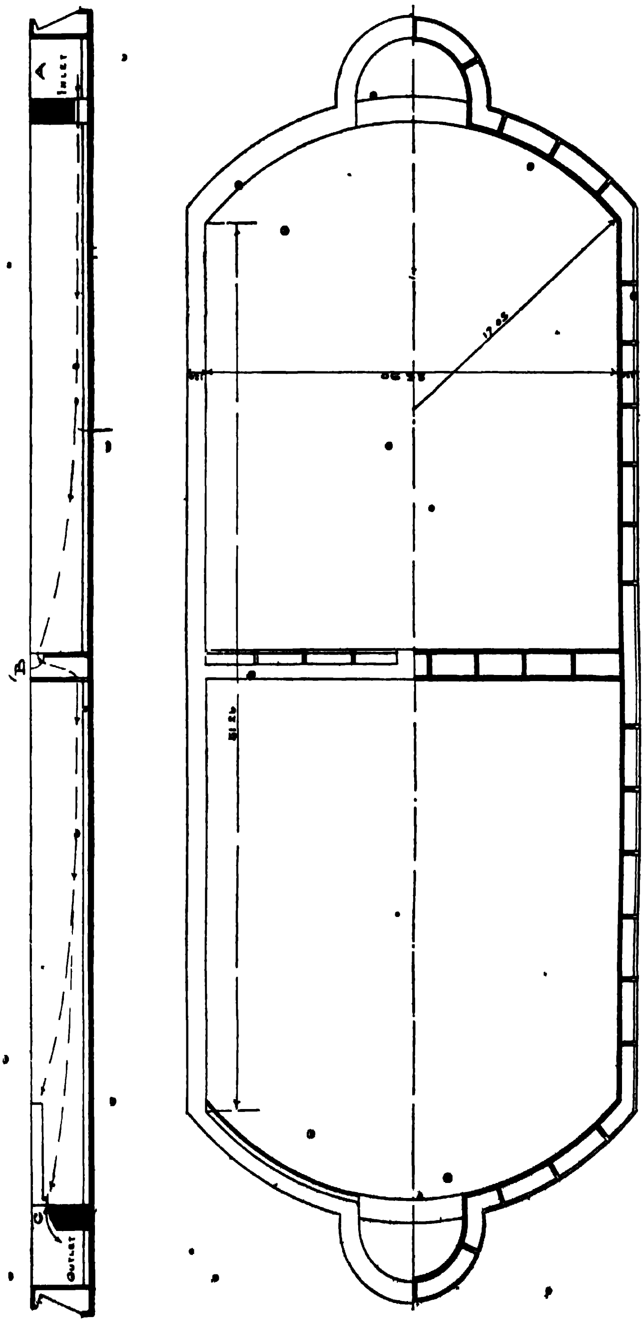


Fig 3 Reinforced Concrete Settling Tank

As the ground on which this settling tank was to be constructed was of a nature which

precluded any hope of obtaining a uniform foundation, it was decided to flood the whole surface until such time as all voids had been filled and infiltration ceased, and for this purpose one of the unfiltered water-pumps was utilised during fifteen days, pumping altogether about 8,000,000 gallons before this result was obtained.

On the ground drying off, a 20-ton steam roller was run on the land, and rolling continued until the surface was brought to a uniform level and no further

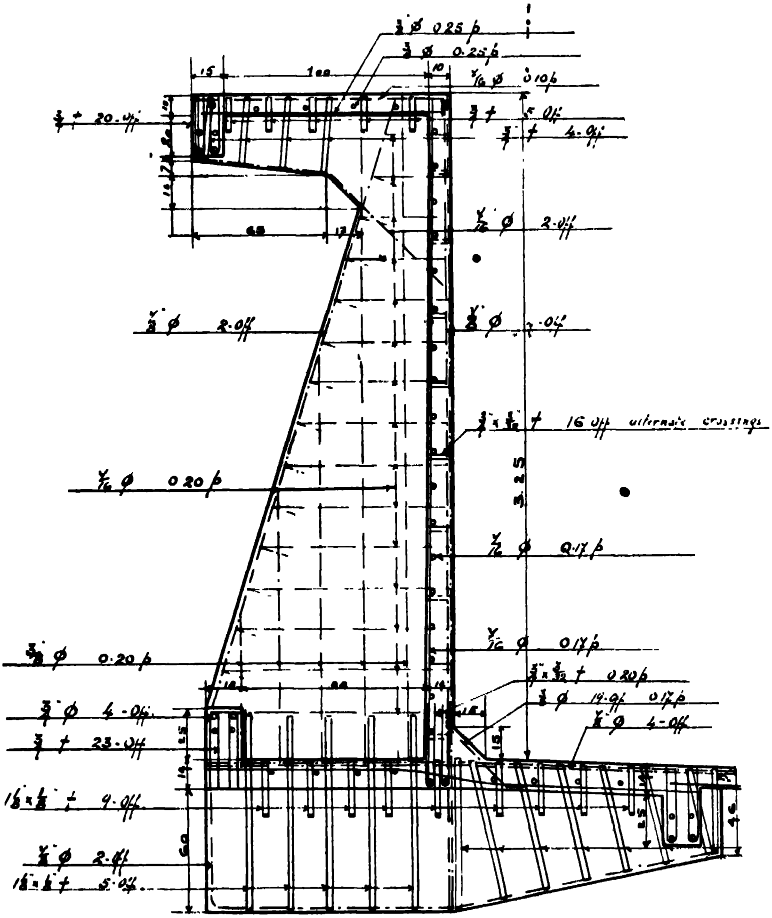


Fig. 4. Details of Reinforcement.
REINFORCED CONCRETE SETTLING TANK.

settlement visible when the roller was at work. An examination of the land after this proved so satisfactory that it was decided to dispense with anything further in the way of foundations, and work was at once commenced in excavating the surface to the exact camber of the tank bottom, and on this a dry course of broken stone was rammed, sufficient only to form a clean surface on which to lay the reinforced concrete.

The design adopted shows remarkably well the economy of material to be

obtained from the use of reinforced concrete for this class of work. The bottom

Fig. 5. Reinforced Concrete Settling Tank

of the tank is a continuous slab, 4 in. thick, reinforced longitudinally and

transversely by $\frac{3}{8}$-in. rods pitched 8 in. centre to centre each way. The side

Figs. 6 & 7. In Course of Construction.
REINFORCED CONCRETE COTTON STORES.

walls are $5\frac{1}{2}$ in. thick at the base, tapering to 4 in. at the top, and supported

throughout their length by buttresses pitched 11 ft. 6 in. centre to centre. A 4-ft. platform runs round the tank for inspection purposes, and in the manner of its attachment to the side walls and buttresses advantage is taken of its position to render that part of the side wall contained between the buttresses as a slab supported on all four sides, thus keeping these at a minimum for thickness and reinforcement. Details of the reinforcement in the buttresses and its attachment to the rest of the tank are given in *Fig.* 4. This also shows the beam placed on the inner side of the side wall and under the bottom slab to take the negative bending moment, due to the weight of the side walls, when the tank is emptied for cleaning purposes.

The composition of the concrete throughout the entire work was made in the following proportions: 1 cubic metre of gravel screened through a $\frac{3}{4}$-in.

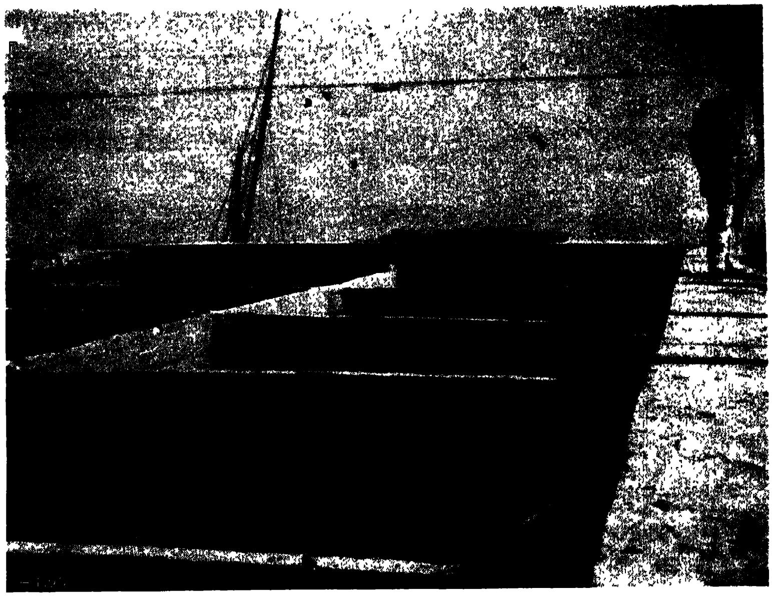


Fig. 8.
REINFORCED CONCRETE PONTOON BREAKWATER

ring, $\frac{1}{2}$ cubic metre of sand, and 350 kilos. of cement, the whole being mixed by hand, then watered and mixed to a wet concrete.

In order to prevent infiltration the bottom of the tank was covered by a continuous sheet of Aqualite Bitumen Sheeting, over which was laid a protecting layer of concrete 2 in. thick, the side walls being rendered with a 2 to 1 cement mortar worked to a finished surface. As regards the side walls, it is interesting to note that the results obtained have been perfectly dry outer surfaces, and this result is the more remarkable when taken into consideration with the extreme ranges of temperature to which these exposed walls are daily subjected.

The aforementioned works have all been designed and executed under the direction of Mr. H. R. C. Blagden, M.I.M.E., the General Manager of the Alexandria Water Company, Ltd.

Another use for which reinforced concrete is finding increased favour in Alexandria is in the construction of cotton stores, or "chounahs" as they are locally called. These chounahs are of immense size, and in view of the exceedingly valuable nature of their contents (many chounahs have cotton stored to the extent of over half a million sterling during the busy season) one of the essential points in their construction is fire-resisting qualities. The most recent practice in building these is to construct a skeleton work consisting of reinforced concrete columns pitched longitudinally and transversely at equal distances, these columns supporting the floors and roofs, which are made of the same material. The outside walls are of siliceous sand bricks, laid as panels between the columns, the interior division of the chounah into separate compartments being provided for in a similar manner.

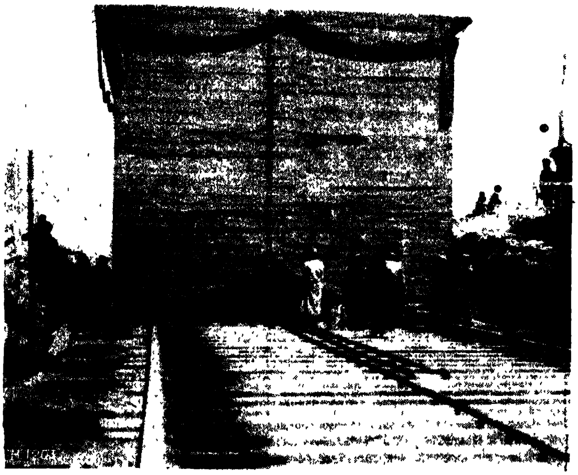
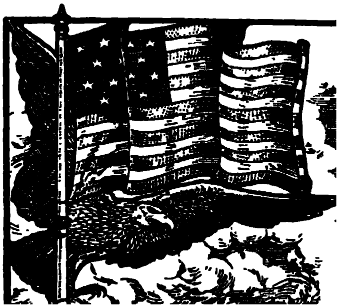


Fig. 9.
LAUNCHING PONTOON BREAKWATER.

Although from the æsthetic point of view these buildings leave much to be desired, yet for strength, low cost of upkeep, and immunity from fire risks they are an immense improvement over those chounahs constructed at an earlier date, and wherein the floors, roofs, and columns are in woodwork.

In the harbour several notable works in reinforced concrete have been carried out under the direction of Monsieur Jondet, the Chief Engineer of the Port. These include a small breakwater built in pontoon form on land, launched, towed into position, and sunk. Latterly the same engineer has been responsible for the construction of a lighthouse on the same principle. The lighthouse in question marks the entrance to the main channel and replaces a steel structure destroyed during the winter storms. After the site had been carefully levelled by divers the base or foundation of the structure, which was built as a monolith and in the form of an octagonal cone, was launched and floated into position, and after this was sunk and ballasted the superstructure or lighthouse proper was added *in situ.*



THE PRACTICAL DESIGN OF REINFORCED CONCRETE FLAT SLABS.

By SANFORD E. THOMPSON.*

The following paper was presented at the meeting of the National Association of Cement Users, U.S.A., in March, 1912, and as the designing of Flat Slabs for Reinforced Concrete Work is one claiming considerable attention, we have reprinted the paper here to show some of the views held on the subject in the United States.—ED.

THE purpose of this paper is to present material covering the practical task of designing flat slab floors for reinforced concrete structures. The requisite thickness of slab, amount of reinforcement, and size of column head, for different loadings and different spans, are given in a table; and the theories and assumptions involved in the computation are briefly discussed. Values not included in the table may be worked out from the formula, finding the desired values of C_s and C from the diagrams.† Curves are given also for the constants used in the design of members with steel in top and bottom, and apply not only to flat slabs, but to any beam or slab reinforced both in compression and tension.

For reinforced concrete buildings, the flat slab- or girderless floor, as it is sometimes called- is as cheap, and frequently cheaper, than beam and girder construction. The smooth ceilings with no intersecting beams allow better distribution of the light. The expense and complication of installing sprinkler systems are lessened. The clear headroom for the same story height is increased, or else, on the other hand, the story height may be made less without reducing the effective headroom. This last consideration alone is often important enough to dictate flat slab floors.

With flat slab floors the entire load is supported directly on the columns, which are usually spaced about equally in both directions. The column heads are enlarged so as to give increased resistance in shear and bending at the points where this is most needed. The reinforcing bars run through the slabs over the column heads in four directions, two rectangular and two diagonal.

The simplest way of considering the flat slab is to assume that a portion of the slab extending a certain distance out from the column is a flat, circular plate, similar to a Japanese parasol, but with no slope to its surface. This plate is fixed to the column and is assumed to extend out from it on all sides like a cantilever as far as the line of inflection of the slab, which line—as in other forms of monolithic construction—is about one-fifth of the net span away from the support. The rest of the slab may be considered as entirely separate from the flat circular plates, but simply supported from their outer edges or circumferences.

This is no new theory, but is somewhat similar in effect to that of a uniformly loaded, fixed or continuous beam. To illustrate this in practical fashion, we will take an ordinary beam uniformly loaded and fixed at both ends. This illustration does not in any way show the methods of determining a bending moment in the flat slab, since,

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† For an example of flat slab design worked out in detail see Taylor and Thompson's "Concrete, Plain and Reinforced," 2nd edition, 1911, pages 487 and 488.

as stated below, the actual bending moment is dependent upon the elastic theory. It does, however, show quite clearly that we are justified in assuming the slab to be cut through on the line of inflection.

We know from simple mechanics that the moment at the support of an ordinary uniformly loaded fixed or continuous beam is $Wl/12$* and, at the centre, is $Wl/24$. Now, suppose at the points of inflection, which also by mechanics we know to be located at a distance $0{\cdot}2113l$ from each support, we cut the beam completely through so as to have a cantilever at each end with a simply supported beam between. The bending moment of the cantilever at its support, due to the load upon it, is $0{\cdot}2113W \times 0{\cdot}2113l/2$, and the moment at its support due to the load on the supported beam between cantilevers, is $\frac{1-2(0{\cdot}2113)}{2} W \times 0{\cdot}2113l$. The sum of these two moments is $0{\cdot}0223\ Wl + 0{\cdot}0610\ Wl = 0{\cdot}0833\ Wl$ or $Wl/12$. In other words, while this analysis is not that which can be used for a flat slab, because of the extra strength of the flat slab due to the multiple reinforcement, the division into sections corresponds to our assumption in the flat slab theory. In the same way we might show that the centre moment of the simple beam supported by the two ordinary cantilever beams is $Wl/24$.

Tests of the flat slab construction at Minneapolis† indicate that the line of inflection of a flat slab floor is substantially the same as in a fixed beam, or about 1-5 the net distance between supports, although, as would be expected, the bending moment is entirely different.

PROBLEM OF DESIGN.

The problem of the design of the flat slab, then, resolves itself into (1) a determination of the proper thickness and reinforcement required at the support for the cantilever circular plate supporting its own load and also the load of the rest of the slab, and (2) a determination of the thickness and reinforcement at the centre of the span required for the simply supported section lying between the circular plates.

Various Methods of Design of Slab.—Various methods have been advanced for the design of the flat slab. Some are based merely on deflection tests, which give no true basis for computations; others compute the steel carefully at the centre of the slab, which is not the critical part; others consider the construction to consist of beams between columns with a slab between, thus obtaining ultra-conservative results; while a plan still more common is to take the moment at the supports arbitrarily without regard to the size of the column head. The shear or diagonal tension near the column head is frequently disregarded altogether.

Shear at the Support.—The direct shear at the support, as in any mechanical construction, is equivalent to the total load supported by the column. This shear is readily borne by the concrete and steel. The diagonal tension, however, which, as in a beam, may be considered as measured by direct shear, must be carefully considered. To reduce the diagonal tension and also to increase the resistance to bending of the slab, the column head is enlarged. To still further increase the resistance, a part of the bars in the top of the slab over the supports may be bent down just outside of the supports and then carried along in the bottom of the slab.

In either case, the shearing stress should be limited to definite units, although it seems permissible to use a somewhat higher stress than in a beam.

The diameter of the enlarged column head, which is the actual support of the slab, should be governed by the shearing stress either at its circumference or at a short distance outside of it.

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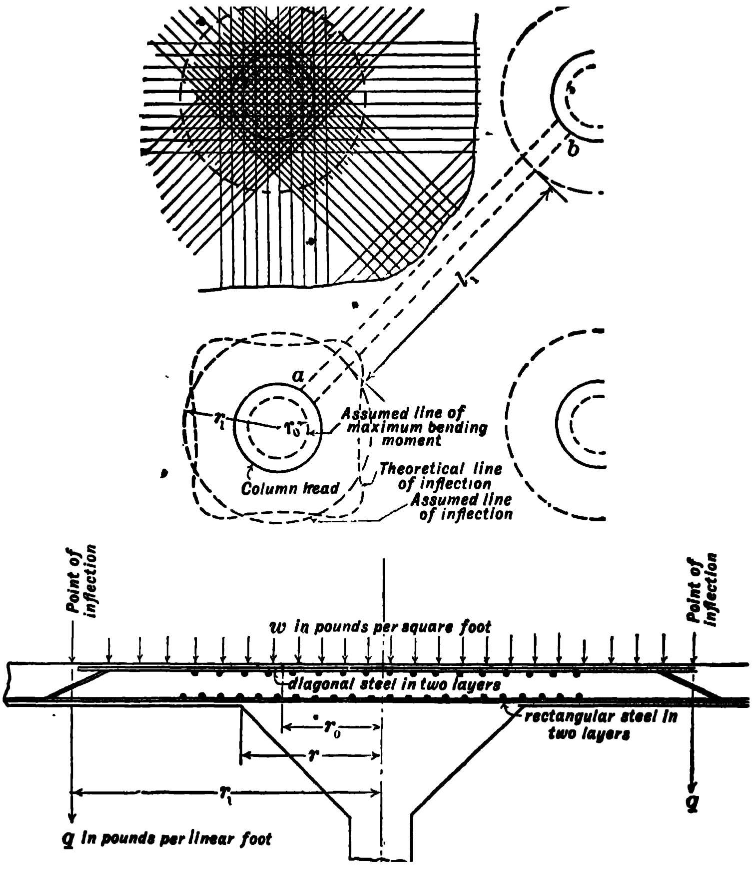
* W=total live plus dead load. l=distance in feet between supports.

† See paper on "A Test of a Flat Slab Floor in a Reinforced Concrete Building," by Arthur R. Lord, *Proceedings National Association of Cement Users* Vol VII., page 156.

Bending Moment at Support.—The theory of flat plates, which must be used in designing a circular plate, is not yet clearly established. By the use of what is termed, in mechanics, the elastic theory, we have a fairly good working hypothesis. The analysis solved by Prof. H. T. Eddy* offers, in the writer's judgment, the most rational solution of the problem yet advanced.

In the design of the flat slab, therefore, the author† has started with Prof. Eddy's analysis of stresses in a homogeneous circular plate, and from his general formulas has deduced by mathematics other formulas applying to circular plates free on their edges and clamped around the columns. In a flat slab thus supported there are



FIGS. 1 & 2. PLAN AND SECTION OF FLAT SLAB.

horizontal stresses at right angles to each other. The effect of these lateral stresses has been taken into account, this being expressed by Poisson's ratio, which is the ratio of the lateral deformation to the deformation in the direction of the stress. The value of this ratio is taken as 0·1, which has been shown by experiments to be a fair value for concrete of 1 : 2 : 4 proportions.

It has been found possible to reduce the complicated formulas derived by the Eddy

* Engineers' Society, University of Michigan, 1899.

† The author is indebted to Mr. Edward Smulski for the computations involving intricate analyses by higher mathematics; also to Mr. John Ayer for further studies in the practical design.

analysis into four formulas which are comparatively simple although still rather complicated for practical use. These formulas are for four bending moments and can be applied not merely to the slab at the support, but to any point in the circular plate surrounding the column. The four moments are as follows:

M_1 = moment produced by the loading that is uniformly distributed over the circular plate and causes circumferential fibre stress.

M_2 = moment produced by this same loading, but which causes radial fibre stress.

M_a = moment produced by the loading from the rest of the slab that is distributed along the outer edge of plate, and causes circumferential fibre stress.

M_b = moment produced by the latter loading, but which causes radial fibre stress.

A study of the analysis, however, shows that the two circumferential moments are a minimum at the support and may be safely disregarded. The two formulas for the radial moment may be combined and still further reduced to the following simple form which can be used for a circle of any radius, r, within the circular plate. The meaning of the symbols is made clearer by reference to *Figs.* 1 and 2, which show the plan and the section of a flat slab.

Let

q = uniformly distributed load around the outer edge of the plate in pounds per foot of length.

w = uniformly distributed load on surface of plate in pounds per sq. ft.

r_0 = radius in feet to line of maximum bending moment (which is within the column head).

r_1 = outer radius of assumed plate in feet.

r = any radius in feet where moment is to be computed; for critical section, r is radius of column head.

C_5, C_e = constants given in *Figs.* 3 and 4.

M_r = total radial bending moment to be used ordinarily.

l_1 = distance in feet between lines of inflection.

Then total radial moment at any point of plate is—

$$M_r = wr_0^2 C_5 + qr_0 C_e$$

For convenience in computation, values of the constants C_5 and C_e, for various values of the ratios r_1/r_0 and r/r_0, are plotted in the curves given in *Figs.* 3 and 4.*

With q expressed in pounds per foot of length, w in pounds per square foot, and r_0 in feet, the moments are in foot-pounds per foot or inch-pounds per inch.

Position of Maximum Bending Moment and of Maximum Stress.—As commonly constructed, the column head flares at the top and is therefore more or less flexible. For this reason the line of maximum bending moment will be located, not at the extreme edge of the column head, but a little within it. The maximum stress, on the other hand, will not be on the line of the maximum bending moment because the strength there (since it is within the head) is increased due to the greater depth of concrete. It is fair to assume, therefore, that the maximum stress is at the edge of the column head, and we may assume the "critical section" as on this line. The exact location of the line of maximum moment is indeterminate. Under ordinary conditions it appears fair to assume its location as within the column head, a distance equal to the thickness of the slab. Therefore, M_r is figured for a value of $r = r_0 + t$. In figuring this moment, values of the constants C and C_e should be taken from the curves in *Figs.* 3 and 4. As in an ordinary fixed beam, this bending moment is negative, so that the upper side of the slab is in tension and the lower in compression. Having found the moment, the design of the reinforcement and the thickness of the slab may be worked out as for an ordinary beam.

The curves in *Figs.* 5 to 8 inclusive will be found of assistance in working out the design.

Steel in Column Head.†—The slab at the column head might be designed with the steel all in the top of the slab running in four directions provided the slab is thick

* These are drawn up from values in tables in Taylor and Thompson's "Concrete, Plain and Reinforced," 2nd edition, 1911, page 518.

† Certain features of flat slab reinforcement are covered by Letters Patent, No. 1003384, of C. A. P. Turner.

enough so that the concrete will not be overstressed in compression. In order to reduce the thickness of the slab, and therefore save the additional cost and weight of concrete over the entire floor, it is economical to place steel in the bottom of the slab as well as the top, and figure it as assisting the concrete to take compression. Since a portion of the bars need to extend only far enough beyond the column head to furnish suitable

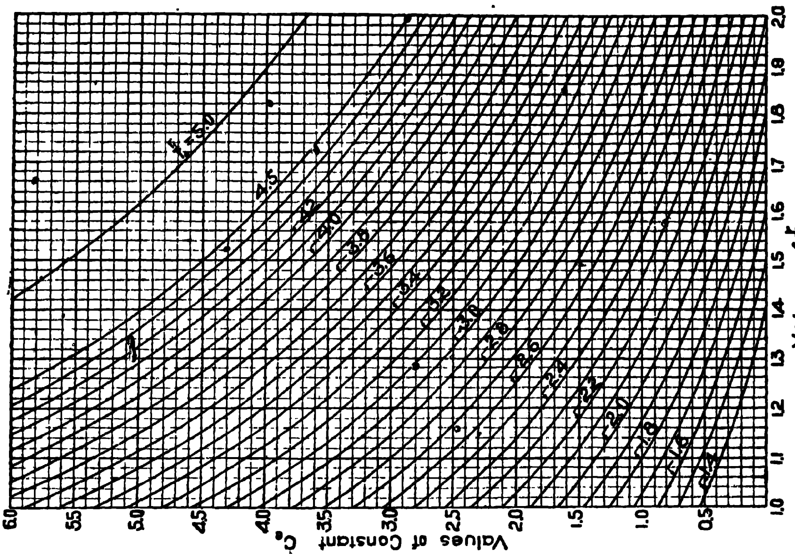


FIG. 4. DIAGRAM GIVING VALUES OF C_e IN FORMULA.
$M_r = wr_o^2C_5 + qr_oC_e$
r_o = radius in feet to line of maximum bending moment.
r_1 = outer radius of assumed plate in feet.
r = any radius in feet where moment is to be computed; for critical section r is radius of column head.

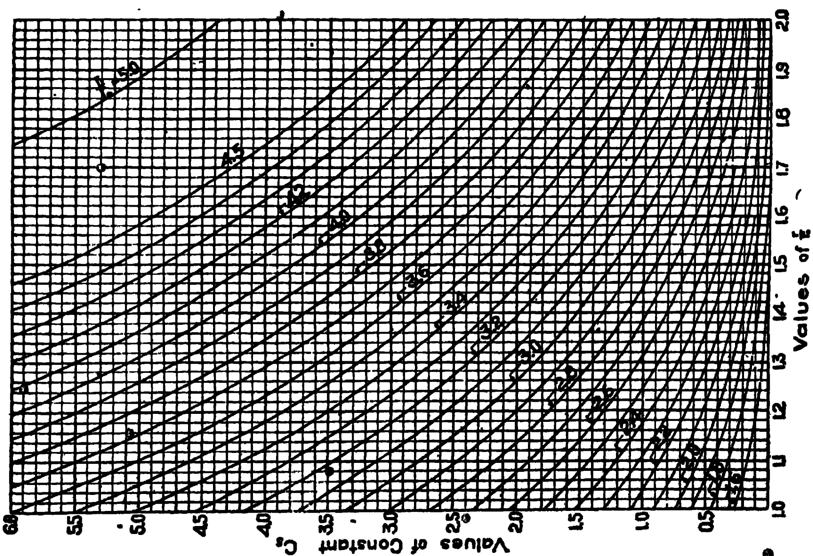


FIG. 3. DIAGRAM GIVING VALUES OF C_5 IN FORMULA
$M_r = wr_o^2C_5 + qr_oC_e$
r_o = radius in feet to line of maximum bending moment.
r_1 = outer radius of assumed plate in feet.
r = any radius in feet where moment is to be computed; for critical section r is radius of column head.

bond, the cost of this additional steel will be much less than the cost of an additional thickness of concrete over the entire slab.

To make it easy to place the concrete and also to bring the centre of gravity of the steel as near to the surfaces of the slab as possible in order to give the longest moment arm, and thus a thinner slab, two layers of steel may be placed in the top of the slab

and two layers in the bottom. The relation of the quantity in the top and bottom must be determined by the design. If a thin slab is desired, even more steel may be placed in the bottom than in the top. In the tables, three ratios of steel are given, and the percentages selected are those that will give the required working stresses in the concrete and the steel.

The Minneapolis test already referred to shows that not only the steel directly over the column head, but the steel for a considerable distance each side, takes tension. In view of this test and of the tests made at the University of Illinois,* it is safe to assume that the steel may be spaced over a distance at least equal to the diameter of the column head plus three times the thickness of the slab.

The determination as to whether the diagonal or rectangular steel should be placed at the top is governed by the relative quantities of each. More steel is required for the diagonal direction through the slab, hence the layers which are largest in section may be run diagonally.

Agreement with Minneapolis Tests.—By our theory it is possible to compute the stresses not only next to the column head, but at any point in the slab. In several cases, knowing the exact location of the points where the deformations were measured in the Minneapolis tests, we have computed the stresses at these points. Using 5·6 in. as the moment arm, and including the radial bars as assisting to take tension, we figure the maximum stress in the steel over the edge of the column as 25,000 lb. per sq. in. under the normal load of 225 lb. per sq. ft., as compared with 20,700 lb. per sq. in. given by Mr. Lord as the actual maximum stress in the floor. This is no greater difference than there ought to be between design and test, and shows our method to be slightly more conservative than the actual test.

The compression in the concrete is more difficult to check since the exact locations of the test points are not given. Computations, however, show unquestionably that our methods are conservative enough to allow for the irregularities in concrete mixtures and the danger of not having perfect concrete at the critical section.

Moment at Centre of Slab.—It is possible to adapt the Eddy theory to the design of the centre of the slab as well as to the supports. In practical design, however, as has been indicated, the thickness of the slab is determined by the thickness at the support, which is always the greater. But, in order to avoid too wide spacing of the bars and to adapt the centre reinforcement to that over the supports, more steel is generally run through the slab than the results of tests would show to be necessary. Consequently, instead of considering this from a theoretical standpoint alone, safe values for the bending moments may be selected, based on general principles of mechanics and qualified by actual tests.

Let l_1 = distance between lines of inflection. This distance will be about three-fifths of the net span between column heads.

For the rectangular reinforcement, if the slabs between the points of inflection were simply supported, we should have a moment of $wl_1^2/8$. However, the bending moment in the Minneapolis tests, based on the maximum stresses under uniform working load, is about $wl_1^2/33$. It would appear amply safe, therefore, to adopt a value of $M = wl_1^2/12$.

For the diagonal reinforcement, the steel runs in two directions, and considering both theory and test, a value of $M = wl_1^2/24$ is conservative to use for the steel in each direction.

Cross Steel Between Columns.—In flat slab floors, cracks are apt to occur between columns on rectangular lines, because, since the span is shorter, the deflection is less than in the centre of the slab. To prevent these cracks, it is advisable to place cross reinforcement of small bars in the top of the slab.

* See paper on "A Test of a Flat Slab Floor in a Reinforced Concrete Building," by Arthur R. Lord, *Proceedings National Association of Cement Users*, Vol. VII., page 182.

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ANNOUNCEMENT.

This journal—the pioneer journal of its kind in the British Empire—was founded in 1906 with the object of primarily meeting the demand for reliable technical and economic information regarding concrete, reinforced concrete, and constructional engineering generally.

The uses of concrete and steel are at present being accorded the closest possible attention throughout the world.

This journal continues to present a reliable digest of the world's latest information on concrete and constructional engineering as applicable to British and Colonial readers. It is intended to serve as a guide to what is being done at home and abroad, and will also serve as the medium for the expression of thought and opinion affected, presented by the ablest exponents on all questions connected with concrete and constructional engineering.

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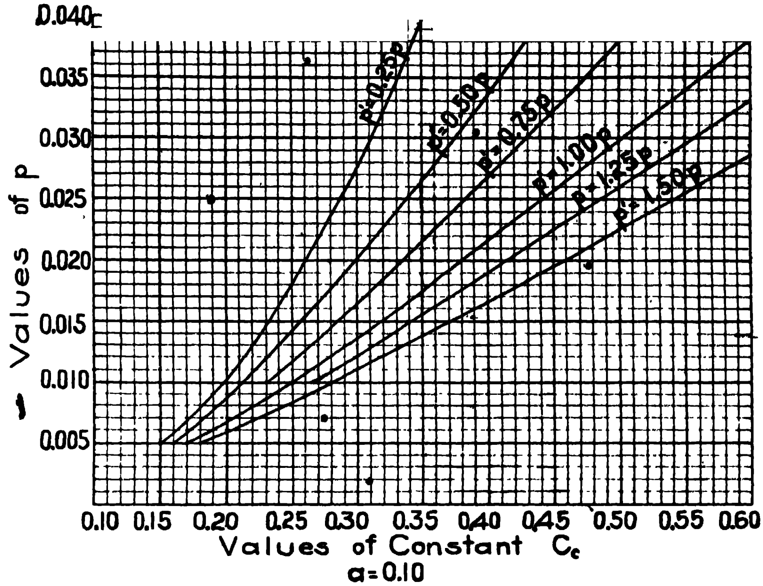
THE SETTING OF PORTLAND CEMENT.

[illegible]

TABLES FOR DESIGN OF SLABS.

The accompanying tables give thicknesses of slab, reinforcement, and size of column head, for various column spacings and loads.



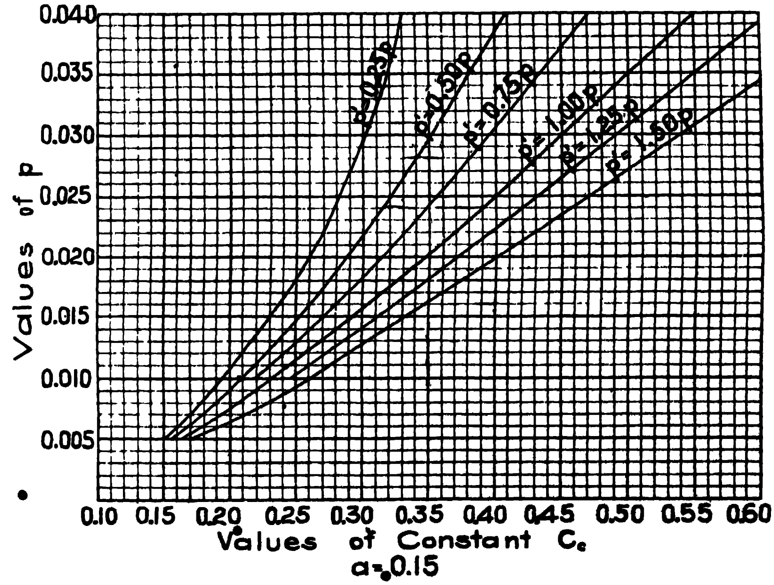


FIG. 5. DIAGRAM GIVING VALUES OF CONSTANTS IN FORMULA

$$f_c = \frac{M}{C_c b d^2} \text{ FOR } a = 0.10 \text{ AND } a = 0.15$$

$$a = \frac{\text{Depth of Steel in Compression.}}{\text{Depth of Steel in Tension.}} \qquad p = \frac{\text{Area of Steel in Tension.}}{\text{Area of Concrete above Steel.}}$$

Three arrangements for steel over the column head are chosen: The first where the area of steel in the top is twice the area of steel in the bottom; the second where

the two are equal; and the third where the area of steel in the bottom is one and a half times that in the top. This gives the designer a variety of thicknesses of slab. The

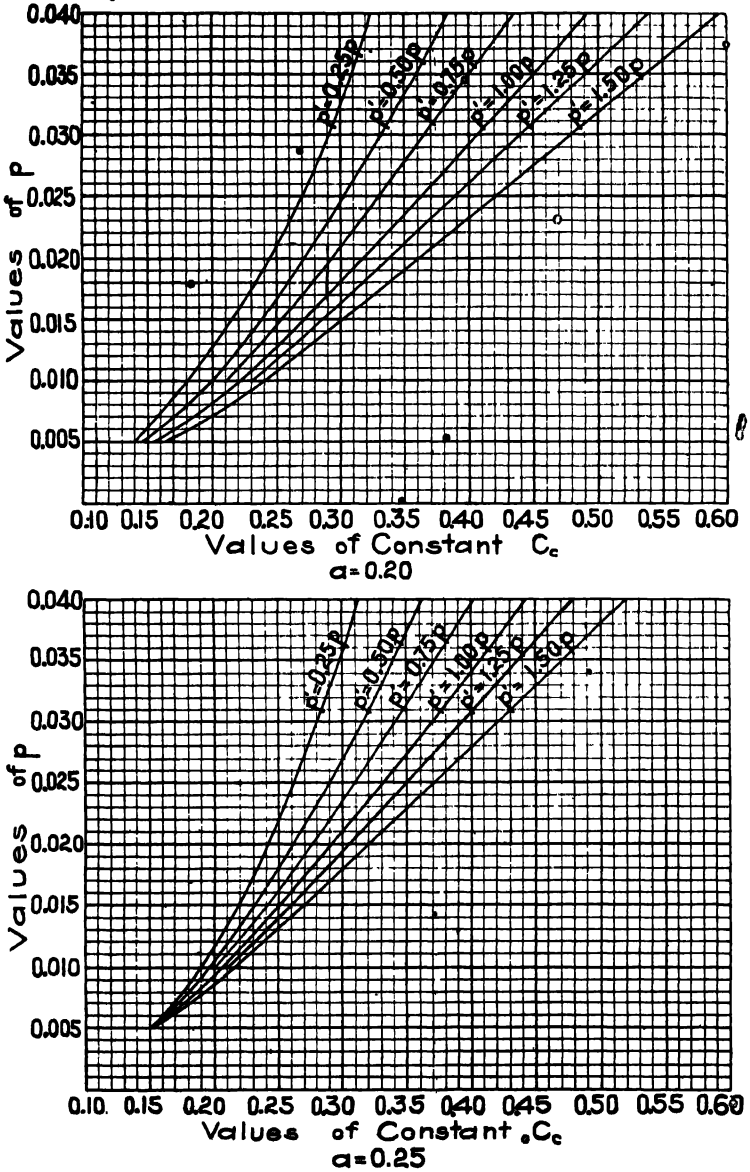


FIG. 6. DIAGRAM GIVING VALUES OF CONSTANTS IN FORMULA

$f_c = \frac{M}{C\, b d^2}$ FOR $a = 0.20$ AND $a = 0.25$

$a = \frac{\text{Depth of Steel in Compression.}}{\text{Depth of Steel in Tension.}}$ $p = \frac{\text{Area of Steel in Tension.}}{\text{Area of Concrete above Steel.}}$

percentages of steel selected are those which produce, with the given conditions, a compressive stress of 800 lb. per sq. in. in the concrete and 16,000 lb. in the steel. In

order to allow 800 lb. in the concrete, it should be mixed in proportions as rich as one part cement to two parts fine aggregate to four parts coarse aggregate. Poisson's ratio is assumed as 0·1, which from recent tests appears to be a fair value.

The size of column head has been figured for a shear of 60 lb. per sq. in. on a circle a distance, t (the thickness of slab), outside of the column head. This shear is used simply as a measure of the diagonal tension. The value is somewhat larger than is permitted in beam design, but appears to be warranted in the case of flat slabs.

The steel in the centre of the slabs has been figured for a stress of 16,000 lb.

Diagrams for Designing Slabs.—To provide for cases not covered by the table, curves for values of C_s and C_e are given, so that the moment under various conditions

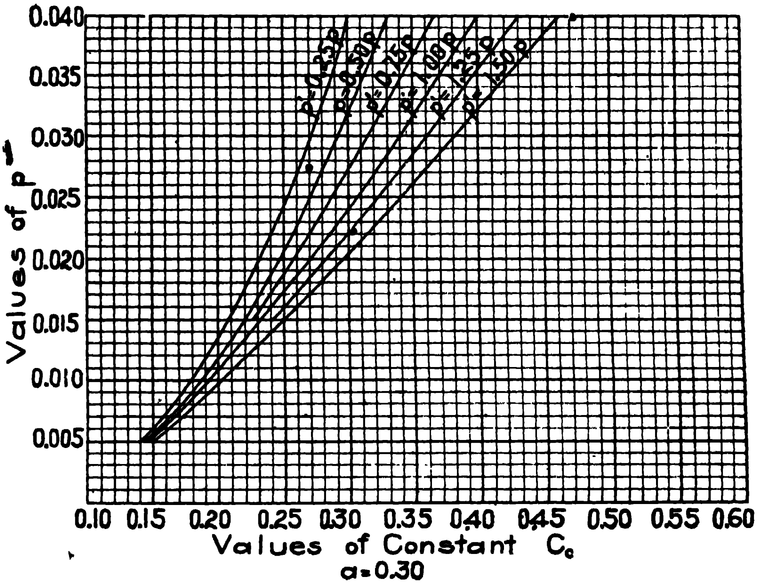


Fig. 7. Diagram Giving Values of Constants in Formula

$$f_c = \frac{M}{C_c b d^2} \text{ FOR } a = 0.30$$

$$a = \frac{\text{Depth of Steel in Compression.}}{\text{Depth of Steel in Tension.}} \qquad p = \frac{\text{Area of Steel in Tension.}}{\text{Area of Concrete above Steel.}}$$

can be readily figured from the formula for the bending moment given in a preceding paragraph.

Diagrams for Determining Steel in Top and Bottom of Beams or Slabs.—In *Figs.* 5 to 8, curves are plotted for finding the values of the constants C_c and C_s in the formulas for the steel and concrete stresses in beams or slabs with steel in top and bottom. The curves are drawn for different values of a, the ratio of distance of steel in compression from compression surface to distance of steel in tension from compression surface, and for different values of p'/p, where p=ratio of cross-section of steel in tension to concrete above it,* and p'=ratio of cross-section of steel in compression to this same area of concrete.

* Where the tension steel is at the top, as over the support of a flat slab or beam, the concrete area is taken below the tension steel.

TABLE I.—DESIGN OF FLAT SLABS.

THICKNESS OF SLAB, AREAS OF STEEL AND SIZES OF COLUMN HEAD ARE GIVEN FOR DIFFERENT SPANS AND PERCENTAGES OF STEEL.

Live Load 100 lb. per sq. ft.

Span between centres of columns in feet. ft.	Ratio of cross-section of steel in tension to concrete below steel. (p)	Ratio of cross-section of steel in compression to concrete below steel in tension. (p')	Distance from bottom of slab to centre of gravity of steel in tension. (d) in.	Approximate total depth of slab. (t) in.	Diameter of column head. ft.	*Area of steel over column in tension. sq. in.	*Area of steel over column in compression. sq. in.	Minimum area of steel between columns per foot of width of diagonal band. sq. in.	Minimum area of steel between columns per foot of width of rectangular band. sq. in.
12	0·014	0·007	4½	5½	2·00	4·50	2·25	0·16	0·09
12	0·017	0·017	3¾	5	2·00	4·81	4·81	0·17	0·09
12	0·022	0·033	3½	4¾	2·50	7·26	10·90	0·18	0·09
14	0·014	0·007	5	6¼	2·25	5·94	2·97	0·19	0·11
14	0·017	0·017	4½	5¾	2·75	7·93	7·93	0·20	0·11
14	0·022	0·033	4	5¼	3·00	9·96	14·95	0·21	0·11
16	0·014	0·007	6	7½	3·00	9·51	4·76	0·22	0·12
16	0·017	0·017	5¼	6½	3·25	10·95	10·95	0·23	0·12
16	0·022	0·033	4½	5¾	3·75	14·01	21·05	0·24	0·12
18	0·014	0·007	6¾	8¼	3·50	12·48	6·24	0·26	0·14
18	0·017	0·017	6	7½	3·75	14·42	14·42	0·27	0·14
18	0·022	0·033	5	6¼	4·50	18·67	28·00	0·28	0·14
20	0·014	0·007	7¾	9¼	4·00	16·36	8·18	0·30	0·16
20	0·017	0·017	6¼	8¼	4·50	19·47	19·47	0·31	0·16
20	0·022	0·033	5¾	7¼	5·00	23·89	35·80	0·32	0·15
22	0·014	0·007	8½	10¼	4·50	20·21	10·11	0·34	0·18
22	0·017	0·017	7½	9	5·00	24·05	24·05	0·34	0·17
22	0·022	0·033	6½	8	5·75	31·05	46·60	0·35	0·16
24	0·014	0·007	9½	11¼	5·00	25·10	12·55	0·38	0·20
24	0·017	0·017	8¼	10	5·75	30·41	30·41	0·39	0·20
24	0·022	0·033	7	8½	6·50	37·80	56·70	0·40	0·19

* Area of steel over column head = circumference of column head in inches × d × p or p' depending upon whether the steel is in tension or compression. This steel is assumed as distributed over the entire widths of the bands. Thus if a band of steel has 2 sq. in. steel in section, the area, effective, for two bands will be 8 sq. in. (See example.)

TABLE II.—DESIGN OF FLAT SLABS.

THICKNESS OF SLAB, AREAS OF STEEL AND SIZES OF COLUMN HEAD ARE GIVEN FOR DIFFERENT SPANS AND PERCENTAGES OF STEEL.

Live Load 150 lb. per sq. ft.

Span between centres of columns in feet. ft.	Ratio of cross-section of steel in tension to concrete below steel. (p)	Ratio of cross-section of steel in compression to concrete below steel in tension. (p')	Distance from bottom of slab to centre of gravity of steel in tension. (d) in.	Approximate total depth of slab. (t) in.	Diameter of column head. ft.	*Area of steel over column in tension. sq. in.	*Area of steel over column in compression. sq. in.	Minimum area of steel between columns per foot of width of diagonal band. sq. in.	Minimum area of steel between columns per foot of width of rectangular band. sq. in.
12	0·014	0·007	4¾	6	2·25	5·64	2·82	0·18	0·10
12	0·017	0·017	4¼	5½	2·50	6·81	6·81	0·19	0·10
12	0·022	0·033	3¾	4¾	3·00	8·72	13·09	0·21	0·10
14	0·014	0·007	5½	7	3·00	8·72	4·36	0·22	0·12
14	0·017	0·017	5	6¼	3·50	11·22	11·22	0·23	0·11
14	0·022	0·033	4¼	5½	3·75	13·22	19·82	0·24	0·11
16	0·014	0·007	6½	8	3·50	12·03	6·02	0·26	0·14
16	0·017	0·017	5¼	7¼	3·75	13·83	13·83	0·27	0·13
16	0·022	0·033	4¾	6	4·50	17·75	26·60	0·28	0·13
18	0·014	0·007	7¼	8¾	4·00	15·32	7·66	0·31	0·16
18	0·017	0·017	6¼	7¾	4·50	18·05	18·05	0·32	0·15
18	0·022	0·033	5¼	6¾	5·50	24·00	36·00	0·33	0·14
20	0·014	0·007	8¼	10	5·00	21·80	10·90	0·34	0·17
20	0·017	0·017	7	8¼	5·50	24·70	24·70	0·35	0·17
20	0·022	0·033	6	7½	6·25	31·14	46·70	0·36	0·16
22	0·014	0·007	9	10½	5·50	26·15	13·08	0·38	0·18
22	0·017	0·017	7¾	9¼	6·25	31·07	31·07	0·39	0·17
22	0·022	0·033	6¾	8¼	7·00	39·24	58·80	0·40	0·17
24	0·014	0·007	9½	11¼	7·00	36·05	18·03	0·42	0·21
24	**0·016**	**0·018**	**8½**	**10½**	**7·00**	**36·95**	**29·57**	**0·43**	**0·20**

The values printed in black type are figured for a column head 7 ft. in diameter, and the thickness of the slab is increased to withstand the shear. If the reinforcing rods are so bent that more than 60 lbs. in shear can be allowed on the concrete, the thickness of the slab may be decreased provided the steel areas are increased sufficiently to give the desired strength.

*** Area of steel over column head = circumference of column head in inches × d × p or p' depending upon whether the steel is in tension or compression. This steel is assumed as distributed over the entire widths of the bands. Thus if a band of steel has 2 sq. in. steel in section, the area, effective, for two bands will be 8 sq. in. (See example.)**

TABLE III.—DESIGN OF FLAT SLABS.

THICKNESS OF SLAB, AREAS OF STEEL AND SIZES OF COLUMN HEAD ARE GIVEN FOR DIFFERENT SPANS AND PERCENTAGES OF STEEL.

Live Load 200 lb. per sq. ft.

Span between centres of columns in feet. ft.	Ratio of cross-section of steel in tension to concrete below steel. (p)	Ratio of cross-section of steel in compression to concrete below steel in tension. (p')	Distance from bottom of slab to centre of gravity of steel in tension. (d) in.	Approximate total depth of slab. (t) in.	Diameter of column head. ft.	*Area of steel over column in tension. sq. in.	*Area of steel over column in compression. sq. in.	Minimum area of steel between columns per foot of width of diagonal band. sq. in.	Minimum area of steel between columns per foot of width of rectangular band. sq. in.
12	0·014	0·007	5	6¼	2·50	6·60	3·30	0·20	0·10
12	0·017	0·017	4½	5¾	3·25	9·38	9·38	0·21	0·10
12	0·022	0·033	3¾	5	3·75	11·70	17·55	0·23	0·10
14	0·014	0·007	6	7½	3·25	10·31	5·16	0·24	0·13
14	0·017	0·017	5	6¼	3·75	12·02	12·02	0·25	0·12
14	0·022	0·033	4¼	5½	4·50	15·88	23·80	0·26	0·11
16	0·014	0·007	6¾	8¼	4·00	14·26	7·13	0·28	0·14
16	0·017	0·017	5¾	7¼	4·50	16·60	16·60	0·30	0·14
16	0·022	0·033	4¾	6	5·50	21·70	32·55	0·32	0·14
18	0·014	0·007	7½	9	4·75	18·80	9·40	0·33	0·17
18	0·017	0·017	6¼	8	5·50	22·92	22·92	0·34	0·16
18	0·022	0·033	5½	7	6·50	29·70	44·60	0·35	0·15
20	0·014	0·007	8¼	10¼	5·50	24·71	12·36	0·37	0·18
20	0·017	0·017	7¼	8¾	6·25	29·08	29·08	0·38	0·17
20	**0·019**	**0·029**	**6¼**	**7¾**	**7·00**	**31·35**	**47·85**	**0·39**	**0·18**
22	0·014	0·007	9½	11¼	6·25	31·38	15·69	0·42	0·20
22	**0·016**	**0·012**	**8¼**	**10**	**7·00**	**34·90**	**26·15**	**0·42**	**0·19**
24	**0·014**	**0·006**	**10¼**	**12**	**7·00**	**37·90**	**16·24**	**0·46**	**0·22**

The values printed in black type are figured for a column head 7 ft. in diameter, and the thickness of the slab is increased to withstand the shear. If the reinforcing rods are so bent that more than 60 lb. in shear can be allowed on the concrete, the thickness of the slab may be decreased provided the steel areas are increased sufficiently to give the desired strength.

* Area of steel over column head=circumference of column head in inches $\times d \times p$ or p' depending upon whether the steel is in tension or compression. This steel is assumed as distributed over the entire widths of the bands. Thus if a band of steel has 2 sq. in. steel in section, the area, effective, for two bands will be 8 sq. in. (See example.)

TABLE IV.—DESIGN OF FLAT SLABS.

THICKNESS OF SLAB, AREAS OF STEEL AND SIZES OF COLUMN HEAD ARE GIVEN FOR DIFFERENT SPANS AND PERCENTAGES OF STEEL.

Live Load 300 lb. per sq. ft.

Span between centres of columns in feet. ft.	Ratio of cross-section of steel in tension to concrete below steel. (p)	Ratio of cross section of steel in compression to concrete below steel in tension. (p')	Distance from bottom of slab to centre of gravity of steel in tension. (d) in.	Approximate total depth of slab. (t) in	Diameter of column head. ft.	*Area of steel over column in tension. sq. in.	*Area of steel over column in compression. sq. in.	Minimum area of steel between columns per foot of width of diagonal band. sq. in.	Minimum area of steel between columns per foot of width of rectangular band. sq. in.
12	0·014	0·007	5¼	6¼	3·50	9·72	4·86	0·24	0·12
12	0·017	0·017	4½	5¾	4·25	12·27	12·27	0·25	0·11
12	0·022	0·033	3¾	5	5·00	15·56	23·30	0·26	0·10
14	0·014	0·007	6¼	7¾	4·25	14·03	7·02	0·29	0·13
14	0·017	0·017	5¼	6¼	5·00	16·84	16·84	0·30	0·12
14	0·022	0·033	4¼	5¾	6·00	21·18	31·72	0·31	0·11
16	0·014	0·007	7	8¼	5·00	18·48	9·24	0·33	0·15
16	0·017	0·017	6	7¾	6·00	23·10	23·10	0·35	0·15
16	0·022	0·033	5	6¼	7·00	29·05	43·50	0·35	0·12
18	0·014	0·007	7¾	9¼	6·00	24·59	12·30	0·39	0·17
18	0·017	0·017	6¼	8	7·00	29·18	29·18	0·40	0·16
18	**0·015**	**0·015**	**6¼**	**8¼**	**7·00**	**26·74**	**26·74**	**0·39**	**0·15**
20	0·014	0·007	8¼	10¼	7·00	32·32	16·16	0·43	0·19
20	**0·015**	**0·011**	**8¼**	**10¼**	**7·00**	**33·65**	**25·36**	**0·43**	**0·18**
22	**0·012**	**0·003**	**10¼**	**12¼**	**7·00**	**34·00**	**8·50**	**0·47**	**0·22**
24	**0·010**	**0·000**	**13¼**	**15¼**	**7·00**	**35·64**	**0·00**	**0·51**	**0.25**

The values printed in black type are figured for a column head 7 ft. in diameter, and the thickness of the slab is increased to withstand the shear. If the reinforcing rods are so bent that more than 60 lb. in shear can be allowed on the concrete, the thickness of the slab may be decreased provided the steel areas are increased sufficiently to give the desired strength.

* Area of steel over column head=circumference of column head in inches $\times d \times p$ or p' depending upon whether the steel is in tension or compression. This steel is assumed as distributed over the entire widths of the bands. Thus if a band of steel has 2 sq. in. steel in section, the area, effective, for two bands will be 8 sq. in. (See example.)

EXAMPLE.

For a warehouse floor with a live load of 150 lb. per sq. ft. and a column spacing of 20 ft. each way, what is the necessary thickness of slab, size of column head, and amount of steel?

Solution. —From Table 2 the thickness of slab is given as 8½ in., the size of column head as 5·5 ft., and the area of steel as 24·7 sq. in. at top of slab and same amount at bottom of slab over column, using ratio of area of steel in tension to area of concrete below steel as 0·017. Dividing these values by 4, as each end of the bands is

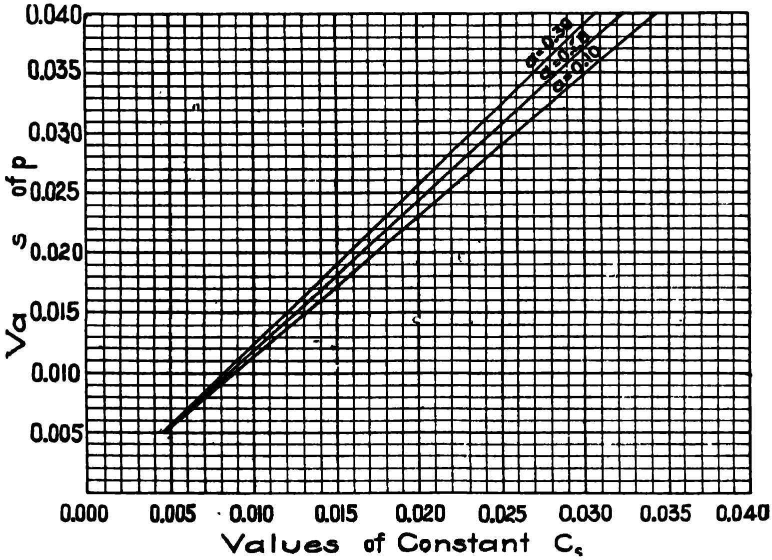


FIG. 8. DIAGRAM GIVING VALUES OF CONSTANTS IN FORMULA

$$f_s = \frac{M}{C_s b d^2}$$

$$i = \frac{\text{Depth of Steel in Compression.}}{\text{Depth of Steel in Tension.}} \qquad p = \frac{\text{Area of Steel in Tension.}}{\text{Area of Concrete above Steel.}}$$

effective, we have 24·7/4=6·2 sq. in. as the area of steel in each band. For this may be used twenty ⅝-in. round bars spaced 5 in. centre to centre for both tension and compression steel.

The amount of steel required at centre of rectangular band is 0·17 sq. in. per ft. of width. Placing a ⅝-in. round bar every 10 in. gives more than the necessary area, but ease in placing the steel makes up for the extra amount. The amount of steel required at centre of diagonal band is 0·35 sq. in. per ft. of width. ⅝-in. round bars every 10 in. will thus give necessary amount of steel.

AN INTERESTING REINFORCED CONCRETE DOME.

By DR. A. KLEINLOGEL, Lecturer in Darmstadt Technical College.

The effectiveness of reinforced concrete from the point of view of economy in space and from the artistic standpoint is well shown in the restoration of the dome described in the following article. We would here mention that we are indebted to the Journal, "Beton v. Eisen," for our illustrations.—ED.

THE health resort of St. Blasien, situated amongst beautiful pine woods in the southern part of the Black Forest, has been celebrated for centuries, and not least for its venerable Benedictine abbey, although the latter has long been given over in part to industrial purposes. The old monastery buildings are occupied by an extensive spinning mill, and only the central building, conspicuous even at a distance by its dome (*Fig.* 1), remains devoted to ecclesiastical purposes. In 1874, however, an extensive fire broke out in the adjacent spinning mill, which also destroyed the wooden framework of the dome. Whilst in 1883 the outer dome thus destroyed was replaced by one of iron covered with wood and copper, it was only possible in 1910 to complete the inner structure of the church — namely, by separating the interior from the iron dome by a fireproof reinforced concrete saucer dome.

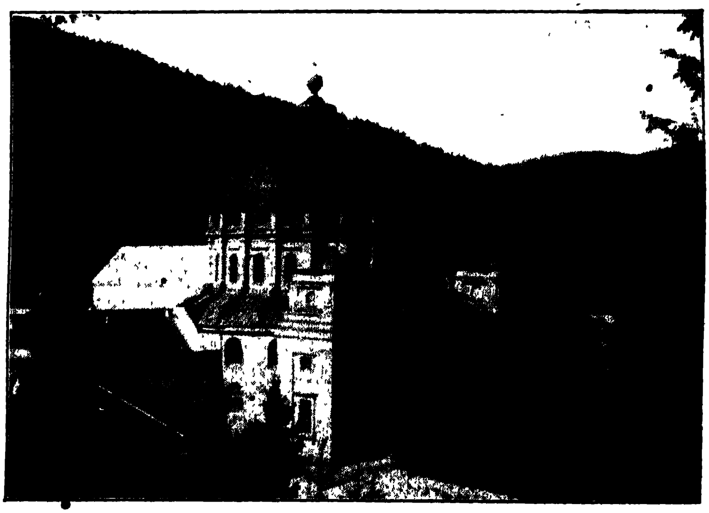


Fig. 1. View of External Iron Dome of the Church.
A REINFORCED CONCRETE DOME AT ST. BLASIEN, GERMANY.

The light construction of the outer dome did not permit of suspending the saucer dome from it. It had also to be taken into account that the outer walls and the drum had suffered damage from the fire, so that it was a fundamental condition that the old walls should be spared as much as possible. There were

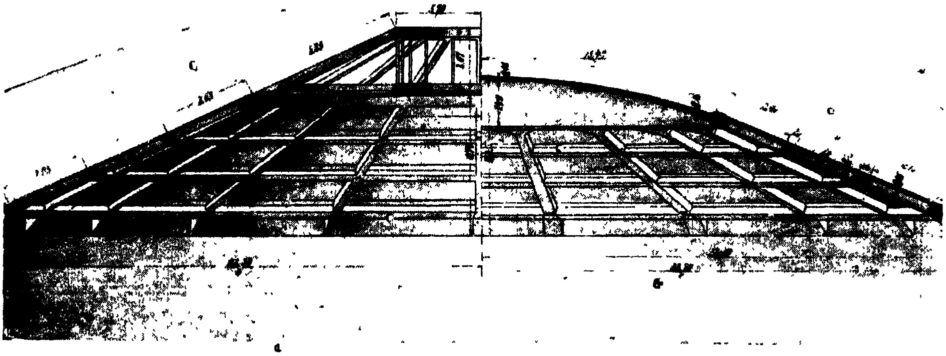


Fig. 2. *Left*—Original Design; *Right*—Construction of Saucer Dome finally adopted.
A Reinforced Concrete Dome at St. Blasien, Germany.

further conditions connected with the existing structure, so that ultimately a shallow construction in reinforced concrete was adopted (*Fig.* 2, right half), which is in the upper part a flat dome of 15·4 metres diameter and 1·5 metres rise, and in the lower part a 20-sided tent-vault, of 33·7 metres span and 5·25 metres height. The upper part is painted with casein colours on a double lime

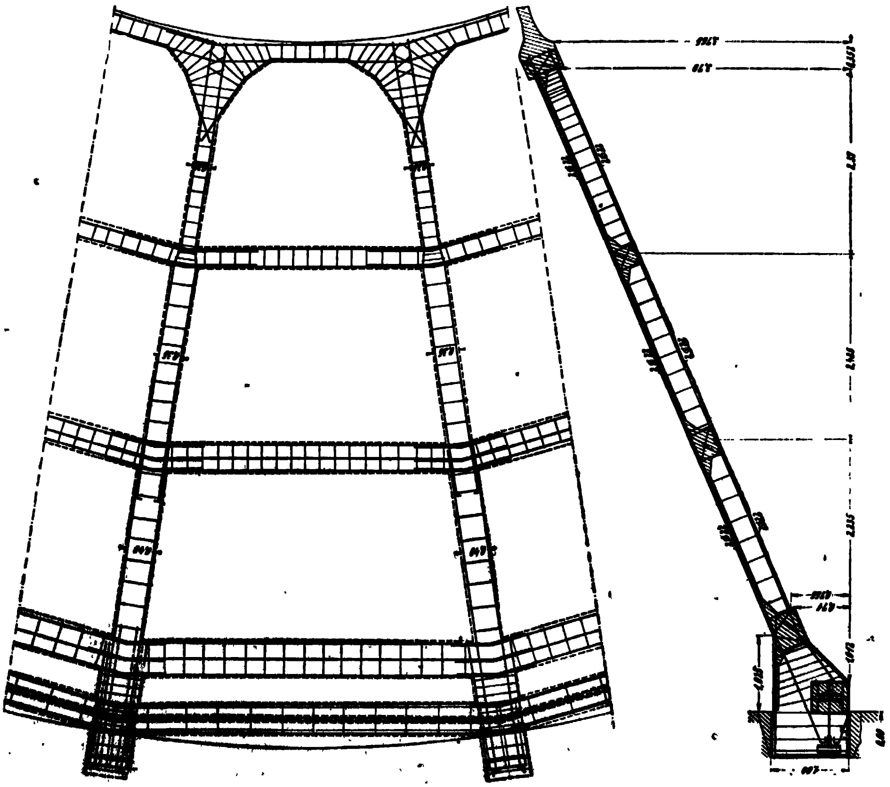


Fig. 3. Details of Reinforcement.
A Reinforced Concrete Dome at St. Blasien, Germany.

plastering by the artist, Georgi, of Karlsruhe. In this connection it is interesting to note that the wood framing of this part was, before concreting, covered with crushed granite, free from sand, in order to provide a sufficiently rough surface, free from cement. The tent-vault construction carries a suspended ceiling, or false dome, which hangs from the main structure by about 2,000 galvanised wires, and consists of slabs of Duro material. These slabs are composed of a mixture of plaster with chemical hardening agents and vegetable fibre, such as manilla, and are manufactured in Constance up to 6 square metres in size, and can be reinforced if necessary with steel.

Fig. 4. Underside of Unfinished Structure.
A Reinforced Concrete Dome at St. Blasien, Germany.

In order, as mentioned above, to minimise the strain on the old walls, a method of construction was adopted which must be described as ingenious and well conceived. The lowest tension ring of the dome bears a stress of 156 tons. Had this ring and the ends of the ribs been let into the brickwork, the latter must have been considerably weakened. Instead of this, the ring is carried entirely outside the

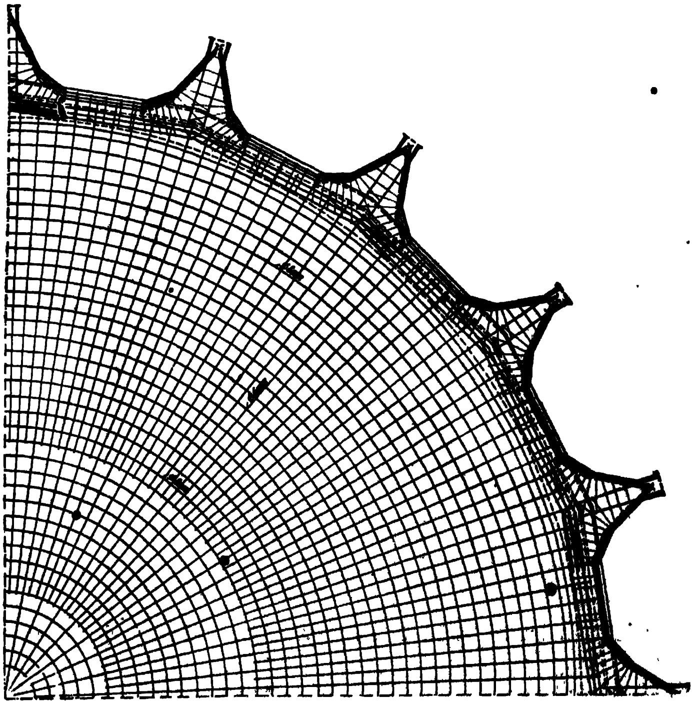


Fig. 5. Reinforcement of the Saucer Dome.
A Reinforced Concrete Dome at St. Blasien, Germany.

masonry, and is free in space (*Fig.* 3). Only such connections are made between the ring and the struts as are necessary, first to suspend the ring and secondly, to transmit the stresses from the struts to the ring. This transmission is effected by means of special shoes constructed of flat and angle irons. In this

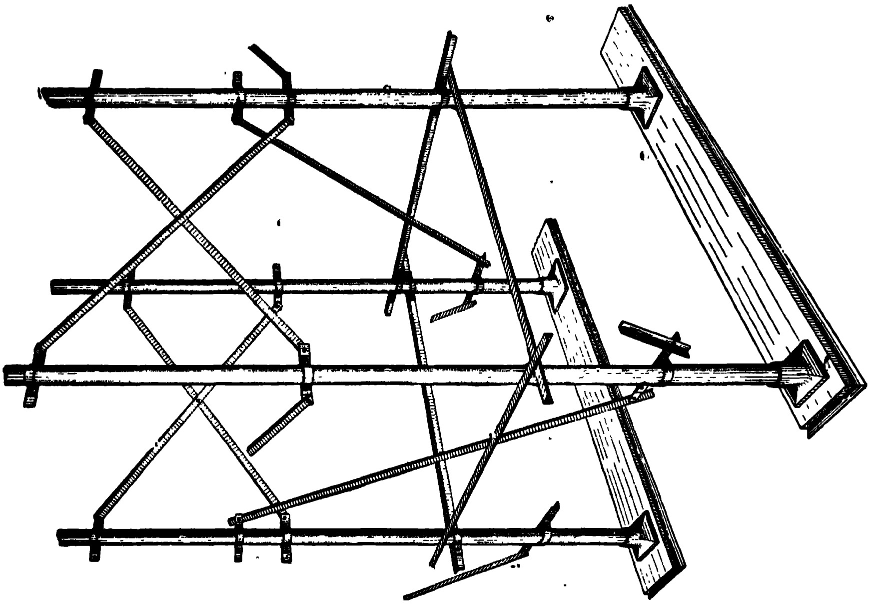


Fig. 7. Details of Steel Scaffolding.
A Reinforced Concrete Dome at St. Blasien, Germany.

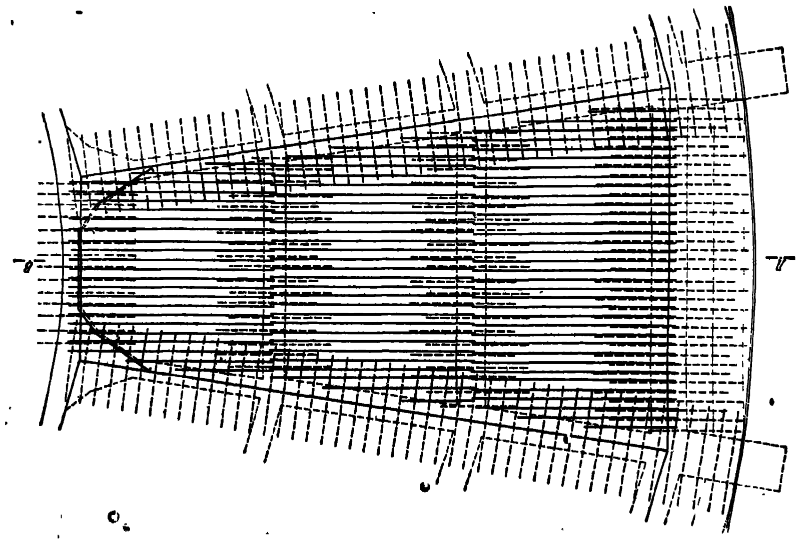


Fig. 6. Reinforcement of Panels between Rings.
A Reinforced Concrete Dome at St Blasien, Germany.

way it was only found necessary to provide single supports for the 20 struts, each only 60 cm. deep and 1 metre high, so that the old masonry was cut into as little as possible.

The small saucer dome transmits its weight to the ribs by means of 20

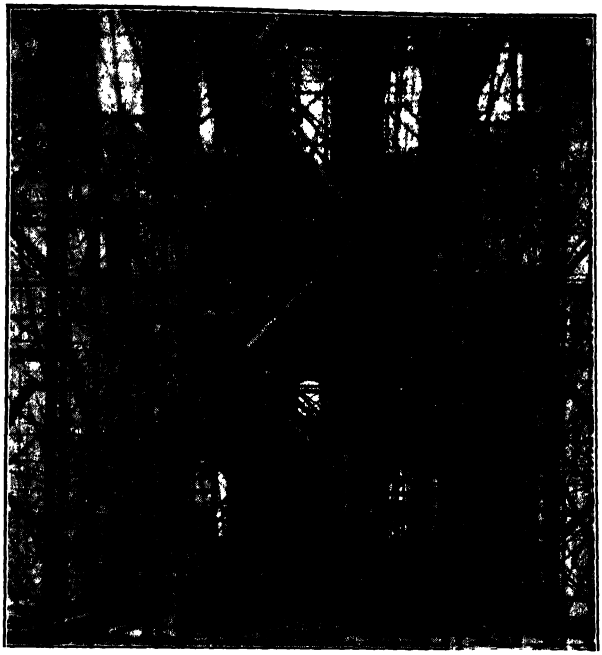


Fig. 8. Steel Scaffolding.

small vaults (*Figs.* 4 and 5). The ribs, again, can move over the wall by sliding bearings, the lower end of each rib and the seating being each provided with a piece of sheet-iron, 3 mm. thick, for this purpose. In order not to endanger the masonry by the lateral thrust of the structure, a straw mat 2 cm. thick is placed as a cushion between the vertical end of each strut and the masonry.

The statical computation of the entire structure was performed by Schwedler's method. The live load was taken as 50 kg./cm.^{2} for the saucer dome and as 100 kg./cm.^{2} for the tent-vault. Snow and wind were excluded by the position of the structure as an inner dome. The rings and ribs,

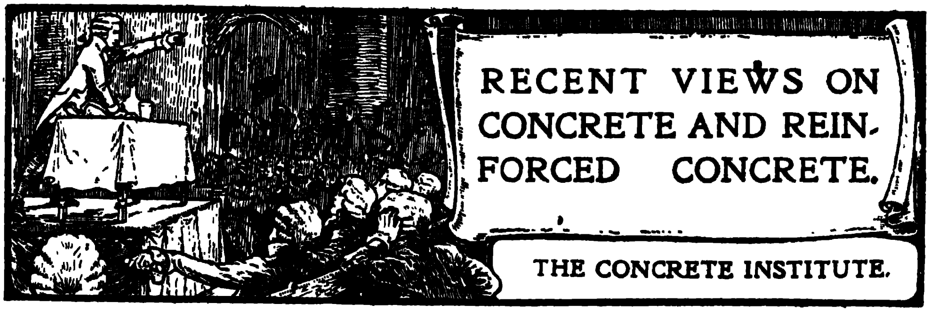
Fig. 9. Saucer Dome Centering partly reinforced.

A Reinforced Concrete Dome at St Blasien, Germany.

the stresses in which are mainly axial, are treated as columns for reinforcement (*Fig.* 3), whilst the intermediate panels are simply reinforced with straight rods (*Fig.* 6). The reinforcement of the saucer dome is composed of an inner and outer steel network, as is best seen in *Fig.* 9, from which the connections of the small dome with the tent-vault may be clearly made out.

Since the height of the dome above the floor is considerable, special centering and scaffolding were required. For this purpose a form of steel scaffold, already employed with success in many instances, was used, the details being shown in *Figs.* 7 and 8. Before use the scaffold was subjected to thorough loading tests and proved itself then and afterwards in actual use thoroughly satisfactory. The scaffolding consisted of steel tubes from 2·5 to 6 metres in length and 70 mm. external diameter, 3 mm. thick; at the joints tubes 50 cm. in length were pushed on with a tight fit. In addition, a number of cross-connections were provided to give the necessary lateral stiffness.

The construction of the dome was carried out at the end of 1910 by the well-known firm of Dyckerhoff and Widmann, 160 cubic metres of concrete and 38 tons of steel being used. The architectural design was due to Prof. Ostendorf and the State architect, Herr Schmieder. The statical computation, and especially the idea of the free-hanging tension ring, were due to the technical director of the firm, Herr Spangenberg, together with Herr Mund. The church is now again in use, and the solution here adopted may lay claim to a union of valuable constructional ideas with artistic effect.



It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

BILLS OF QUANTITIES FOR REINFORCED CONCRETE.

By JOHN M. THEOBALD, F.S.I., M.C.I.

The following is an extract of a paper by Mr. John M. Theobald, F.S.I., M.C.I., read at a meeting of the Institute on November 28th, Mr. E. P. Wells, the President, in the Chair. A lengthy discussion followed, and was continued at a subsequent meeting on December 12th. Of this discussion a short summary is given.

GENERALLY.

AFTER some introductory remarks as to the reasons of the paper and some reference to the question of bills of quantities generally, the methods employed in obtaining same, the author went on to say that at the present time, when an architect decides to construct a building of reinforced concrete he sends a set of plans, sections, and elevations to one or possibly more firms of specialists, who then submit a scheme of construction under their respective systems, together with an approximate estimate of the cost. The firm whose tender is accepted by the architect then prepare their working drawings, which, with a bill of quantities (also supplied by them), are sent to the contractors, and the accepted tender is either incorporated by the quantity surveyor in the quantities sent to the general contractors or is the subject of a separate contract, as the case may be.

REINFORCED CONCRETE.

Reinforced concrete, from his point of view—namely, that of the quantity surveyor—has but recently emerged from a healthy infancy; but, now that its employment is being adopted on all sides, there is a feeling, not confined to the members of his own profession, that the specialist contractor should receive the same treatment as the builder.

In advocating the claims of the quantity surveyor in connection with reinforced concrete, the author was well aware that he would be told that time does not admit of his employment, and that until the details are complete he would be unable to commence his work, and the delay thereby entailed might be considerable. Whilst admitting the objection, his reply was that, if the building were, for argument's sake, a steel-frame building, the steelwork details would have to be prepared, and he felt sure that he would be libelling the members of the Concrete Institute by suggesting that they take longer to supply their details than do the steel manufacturers.

Of course, there may be cases in which rapidity of construction is everything. Under those circumstances, the preparation of bills of quantities by a quantity surveyor is impracticable. He may still, however, be advantageously employed in the preparation of a schedule of prices and subsequent measurement.

PRESENT SYSTEM EMPLOYED BY CONCRETE SPECIALISTS.

Under the present system, the quantities issued by the concrete specialists, by their own showing, are prepared before the working details are complete, and though, granting the necessity (which the author does), he admits that they are in a better position to do their work under these conditions than would be the quantity surveyor, by reason of their employment of constants and formulæ of which he would have no knowledge. It must surely frequently happen, however, that in making the various details it is found necessary to alter the drawings from which the original quantities were prepared, and the latter are, consequently, inaccurate to that extent.

Under the present régime their correctness is not guaranteed, which, assuming for the sake of argument that the drawings from which the building is subsequently erected differ from those from which the quantities were prepared, would seem to press unduly hard upon the contractor. The contractor is mentioned because the author considers the risk in this case is more likely to be his than the building-owners', as the alterations would more probably tend to increase the cost of the building than to diminish it. It is obviously not a point upon which a quantity surveyor can have first-hand knowledge.

FORMS OF CONTRACT FOR REINFORCED CONCRETE CONSTRUCTION.

The forms of contract under which reinforced concrete construction is carried out are, as far as the author's own experience extends, four in number :—

1. The "lump-sum" contract, in which the contractor undertakes to erect the building for a stipulated amount—no mention being made of the method of dealing with any variations that may be made during the progress of the work.

   Anything in the nature of a "lump-sum" contract of this description the author thought most unsatisfactory.
2. The "lump-sum" contract in which the bills of quantities do not form part of the contract, but the contractor undertakes to deposit a copy of his priced bill of quantities, which, as regards prices only, is to form a basis for arriving at the value of any extra or omitted work.
3. The "lump-sum" contract, in which the bills of quantities form part of the contract.
4. The "lump-sum" contract, in which the bills of quantities form a schedule only, and the entire building is remeasured.

VARIATIONS.

If, however, he urged the employment of a fully qualified quantity surveyor for the preparation of quantities for reinforced concrete, he did so even more emphatically when dealing with the question of variations.

It is apparently not usual for the concrete specialists, who prepare the original quantities, to settle the extras and omissions at the completion of the contract. This, at any rate, was the author's experience. The measurement of variations—again speaking personally only—is an acquired taste even when dealing with one's own bill of quantities, but in reinforced concrete, unless under these circumstances, it is anathema.

Quantity surveyors, from bitter experience of variations, have learnt to "take off" with a wealth of detail which would probably surprise many. It would be found that, whereas to the uninitiated the description of the item itself is comprised in half a line of utterly unintelligible abbreviations, a further two or three lines are taken up by a description of the particular portion of the building in which the item occurs.

A short time ago the author was appointed by the building-owner to measure the variations on a reinforced concrete building, with a firm of surveyors appointed by the contractor. The alterations were unusually drastic, and after a preliminary meeting, it was agreed that the specialists should be asked to lend their original dimensions for the purpose of arriving at the omissions. Permission was, of course, readily granted, but upon the contractor's surveyor calling for same, he was shown a small sheet of paper on which, he was informed, were the dimensions in question. Further inquiry elicited the information that the dimensions from which these *totals* were obtained had been destroyed as being of no further use.

Under these circumstances, of course, there was no alternative but to re-measure the omitted work as best possible. Whether the measurements approximated to those originally taken is in the highest degree problematical, and whether the building-owner or the contractor suffered by the measurement will never be known.

This was not a typical case. He did not say for a moment that it is usual to destroy the dimensions when once the totals are obtained, but he did say that engineers, by the very reason of their profession, are not in a position to take off the quantities for their work. The methods of the modern quantity surveyor are the outcome of three, if not four, generations' knowledge of the theory and the practice of his profession, and it has probably taken him between seven and ten years of constant application to acquire it. The education of an engineer—with which term he, of course, included the specialist in reinforced concrete—is even more arduous, and the exercise of both professions in the person of one individual seemed to him almost an impossibility.

ADVANTAGES OF EMPLOYMENT OF QUANTITY SURVEYORS.

The author then went on to argue whether the employment of a quantity surveyor would have obviated any of the disadvantages of the various forms of contract that have been enumerated.

In the first case, that of the "lump-sum" contract purely and simply, the measurement of the extras by him would, the author ventured to think, result in a greater degree of accuracy, and would probably be advantageous from the building-owner's point of view.

In the second case, that of the "lump-sum" contract in which the quantities do not form part of the contract, his employment would be amply justified. For any shortage in the quantities he would be responsible to the contractor, and for any excess of measurement to the building-owner. If he was correct in saying that no responsibility is taken at the present time, the advantages are obvious, both to the building-owner and the contractor; while, assuming an error against the latter, the reinforced concrete specialist would possibly be saved a succession of unpleasant interviews.

In the third example, that of the "lump-sum" contract where the quantities form part of the contract, the advantages of the introduction of the quantity surveyor are chiefly confined to the method of "taking off" the original quantities and the consequent facilities for dealing with the variations. The responsibility is less, admittedly; but the author thought any quantity surveyor worthy of the name would prefer to take the responsibility for the accuracy of his quantities at, of course, a slightly increased fee to compensate him for the risk.

In the last case, where the bills of quantities form a schedule only, and the building is re-measured, he rather fancied that no reinforced concrete specialist would be prepared to give the time to such re-measurement.

METHOD OF MEASUREMENT EMPLOYED.

He did not know to what extent *method* of measurement may be taken as within the scope of his instructions, but he proposed to touch briefly upon the point.

He had in his office at the present time a bill of quantities, prepared by a firm of specialists in reinforced concrete, for a building the cost of which runs well into five figures. It consists of three items—concrete, centering, and reinforcement. The latter is subdivided into three items of rods or bars in various sizes, but beyond, presumably, an inspection of the drawings, this is all the information given to the contractor.

With the greatest respect, the author ventured to say that no contractor, however experienced, can price that bill with any degree of accuracy, and he did not see how he could be expected to do so. He was not saying he would not make a profit on the job, but he did say that he had no idea *what* profit.

The time, however, has now arrived when bills of quantities for reinforced concrete should justify their existence and be, in fact, such as will enable the contractor to form an accurate idea of the work involved, which, in the author's opinion, he cannot do under the present system.

SUGGESTIONS AS TO METHOD OF MEASUREMENT.

In making the following suggestions as to method of measurement, he wanted it to be clearly understood that he was not laying down any hard-and-fast rules. The idea is to obtain the opinions of members.

The tendency under the present conditions seems to be to unite as many items as possible under one description. The author pleaded for a "separation order," and a fuller description of the work involved.

Centering.—In the first place all concrete and centering should be kept separate on the various floors.

The concrete in walls, floors, beams, stanchions, stairs, etc., should also be separated. It was not necessary to further subdivide the concrete. The stanchions, for instance, if octagonal, circular, or circular on square—the beams if tapering, the stairs if flewing—do not entail an additional labour (speaking, of course, of concrete only), and there is, therefore, no object in further separation.

It is on the question of centering that the present system of preparing bills of quantities leaves most to be desired.

The prices of concrete and reinforcement are easily arrived at, and vary but little. The centering is by far the most difficult item for a contractor to price, and it is, therefore, absolutely necessary that the description should be as full as possible and every variation and labour either measured or described.

Wall Centering.—Commencing with wall centering—if circular it should be so described, and the radius given. Then, with regard to the vexed question of deduction for openings. Unless very large, it has hitherto been the custom to assume the centering went across the openings, and, consequently, to ignore them. These openings should be deducted, and a numbered item taken of centering to openings of various widths and heights—averaged where similar in size, *but not otherwise.* This item has been measured per foot run, but, as the chief cost is that of maintaining the supports of the wall centering in which the openings occur, it is essential that the contractor should have the actual sizes—an average of the same would be incorrect because misleading.

Floor Centering.—It need only be mentioned that all raking, or circular cutting and waste, should be measured.

Centering to Beams.—The centering to beams should be measured per foot super—circular being, of course, kept separate—including all cutting at angles, etc. If the beams are splayed on bottom edge, measure either "Extra labour forming splay blank width on edge of beam casing," "Angle fillet blank width and fixing on edge of beam casing to form splay," or, take the item "Including all splayed edges"; the latter, however, the author considered unsatisfactory.

If the beams are irregular or unusual in shape, keep the centering separate and give a sketch.

The centering to small beams, say, 18 in. girth and under, measure per foot run.

Centering to Columns.—The centering to columns and stanchions should be measured per foot super, every variation in the shape being kept separate and fully described. He preferred to include all cutting in the description, but it can, of course, be measured separately, though he saw no object in doing so.

All extra labour, such as from octagonal to square, number as "Extra over centering for —— " giving a full description.

Centering to Stairs.—Centering to stairs should be measured per foot super, as "Centering to sloping soffit of stairs." If "flewing," it should be measured separately.

Edges of Concrete Floors.—All edges of concrete floors, well-holes, sides of steps, etc., should be measured per foot run, giving the thickness, but if 12 in. thick or over, per foot super.

He need hardly say the description of all centering should include for all necessary strutting up from floor below or otherwise supporting.

The steel reinforcement being only of light bar, he did not think it necessary to separate the various weights on each floor.

Bars.—As, however, the prices of the bars vary according to size, until experience teaches which sections could be added together, it was advisable to keep them all separate under a heading on the following lines :—

> The following in bar-steel reinforcement and hoisting and fixing at various levels (not exceeding blank feet from ground).

With regard to the question of bends, hooked ends, etc., he was of opinion that, where the bar reinforcement is of sufficiently small scantling to be bent cold, they can be fairly included in the description, the labour being so small that, if numbered, they

are likely to disproportionately increase the price of the steel. Where, however, they have to be forged, they should be numbered. Stirrups and ties should be numbered, giving the diameter and length of the wire.

It would be advisable, at the commencement of the bill, to describe such of the methods of measurement as might be open to misconstruction by the contractor, as, for instance, that all window openings have been deducted from the wall centering. This will probably only be necessary for a short time; but until contractors have got used to quantity surveyor's methods of net measurement, he considered that any information tending to lessen the risk of misunderstanding is wisely given.

There are, of course, many items which have not been touched upon, but he thought he had sufficiently indicated the principle of the method of measurement to enable criticism to be made.

Conclusion.—Should the employment of quantity surveyors become customary, it will undoubtedly lead to a greater degree of uniformity of method of measurement of reinforced concrete. At the present time the acquaintance of quantity surveyors with the reinforced concrete specialist was not one of long standing, but the author hoped this would soon be remedied.

The President, before the discussion was opened, read a letter from Sir Henry Tanner.

Letter from Sir Henry Tanner, C.B., F.S.O. (Past-President).

"I quite agree with the principles referred to by Mr. Theobald.

"The practice of inviting design and tenders in open competition is, in my opinion, very unsatisfactory; it leads to cutting down of the most vigorous kind, although the design may be within the limit laid down.

"The quantities prepared by specialists are generally based on the French system, which is not very comprehensive in details. It is not unusual to find a staircase put down as one item, whether of stone or wood. This is not what we in England are accustomed to, and the results are difficulty in adjusting variations, and, I presume, in the majority of cases the building owner suflers.

"The necessity of dividing the items mentioned is of the greatest importance, because while the concrete and the steel can be ascertained definitely as a rule—not always—there is nothing to indicate the character of the false work. Therefore, while every care is taken in regard to the first two items to keep them within the total quantities provided, there is no interest whatever in keeping down the false work. Consequently, when a flat slab might be made to meet the case by a small addition of concrete, the builder has to case round raking struts projecting on either side. The raking, cutting, and waste involved are patent to anyone.

"There is another matter having very serious results on the progress of the work, and that is multiplication of sections differing by 32nds of an inch in diameter. The mills cannot be got to put in rolls for the small quantities involved, whereas there would be no difficulty if pains were taken to add a little to some and take off a trifle from others and adjusting distances apart.

"Under the present system the delays that take place at the commencement are appalling. The drawings showing the plans and sections, and generally the positions of the beams and stanchions, are prepared by the architect, and, together with a specification and conditions of contract, are supplied to persons indicating their desire to tender. This labour will be appreciated by architects, and adds considerably to their expenses. With the tenders are supplied some calculations and a few typical details, and the contract having been secured after examination of these details, you are at the tender mercy of the specialist, and he suits himself on the contingencies of his business as to the supply of the rest. It is the builder who is answerable to the building owner, and the specialist can generally shuffle out of any responsibility to his nominee. The consequence is that the ordering of steel is delayed, and the time allowed to the mills is altogether insufficient in normal times.

"In my opinion the specialist, like the architect, should be ready with the whole of his drawings, and the quantities should be properly prepared by a surveyor on the English system. How far the rods should be divided into sizes is a matter rather depending upon price per ton than on any other basis, but hoisting certainly has some small effect. I dare say the builder would put one figure to the lot, but he has the option of doing otherwise. The rod diameters should be as few as possible, and the false work, and hence the concrete placed in the forms, as simple as possible. I do not believe in varying the proportions of the cement; this leads to difficulty and increases the responsibility of the clerk of works, and when one considers that in three or four months the concrete has perhaps doubled in strength there is no need for such niceties and differentiation.

"If reinforced concrete building is to become popular it must be made as simple as possible, which means economy and generally is entirely advantageous.

"My remarks have wandered somewhat from the scope of the paper, but still they all bear on the method to be pursued in tendering. I have had experience of obtaining tenders on the basis of general drawings and quantities, omitting the competition for design, and these have shown very good results—as good, if not better, than those obtained when competitive designs and tenders are resorted to. This latter system does not allow the liberty of alteration that the former is capable of.

"I beg to thank Mr. Theobald for bringing forward the subject, as, in my opinion, the change is a fundamental one and must come."

A letter was also read from Mr. Burton, the Engineer to the West Riding of Yorkshire.

Letter from Mr. W. E. H. Burton, Assoc.M.Inst.C.E., M.C.I.

"I am much obliged to you for your letter enclosing me a copy of the paper to be read by Mr, J. M. Theobald on "Quantities for Reinforced Concrete."

"I have read the same with much interest, and regret that I shall not be able to be present at the meeting; however, I have pleasure in appending a few general remarks on the same.

"If Mr. Theobald's paper results in the quantity surveyor becoming duly recognised as a necessary agent in the carrying out of works in reinforced concrete, it will inaugurate a new era that will be hailed with delight by architects and contractors alike. Under the present system it is well-nigh impossible to secure satisfactory competitive tenders. The number of items in the quantities issued by concrete specialists is too meagre to admit of a contractor forming a complete idea of the work required to be done. The labour in bending bars and placing the reinforcement varies much in the different systems and is a very uncertain factor, and is often misleading to contractors who have not had experience in the particular system; hence such disproportionate tendering. Again, variations appear almost a *sine quâ non,* and without a carefully drawn-up schedule of quantities an equitable settlement cannot be arrived at.

"Quantity surveying has become a science only acquired by years of training and experience, and taking off quantities for reinforced concrete will call for still further attainments on the part of its practitioners. It will mean that they will have to give reinforced concrete a closer study, and be at least capable of checking the various schemes they handle, and advising the architect upon matters of construction and detail.

"On the other hand, the quantity surveyor will require the engineer who formulates the scheme to supply him with an infinitely greater number of drawings, particularly large scale details, than have been considered necessary in carrying out such work in the past.

"Incidentally it will probably lead to more engineers designing their own reinforcements, and not relying so much on the so-called specialists.

"The result will be to secure contractors a fairer basis upon which to tender, clients full value for their money, the architects more facilities in settling up accounts, and thus forward the use of reinforced concrete; and our thanks are due to the author for this able introduction of the subject."

DISCUSSION.

Mr. A. Alban H. Scott, M.S.A. (Member of Council, Concrete Institute), opened the discussion, and referred to Sir Henry Tanner's remarks with regard to architects receiving competitive schemes from so-called specialist firms at some length. "An architect is usually employed to look after the clients' interests, and he cannot look after his clients' interests if he throws the responsibility on to someone who is not a trained or professional person.

"An architect is responsible to his clients if he does not employ a quantity surveyor for reinforced concrete work as for other work, and any trouble that might ensue in a building contract is morally thrown back on the architect.

"Specialists apparently do not attempt to guarantee their quantities; in fact, when anything goes wrong they do not even attempt to justify them.

"Regarding the 'lump sum' contract, any contract is fair if it is entered into by two sane people and provided there is no pressure on entering into that contract."

The speaker then dealt with various other points in the paper at some length.

Mr. T. A. Watson, M.C.I., thought that at the present time there was too much undue haste in the preparation of reinforced concrete schemes, and sufficient time was not given to the contractor or the concrete specialist to prepare and price the various schemes. There was one thing: if Mr. Theobald's suggestion was carried out, it meant practically the abolition of competition between various reinforced concrete specialists. If Mr. Theobald's scheme were carried out the architect or the building owner would have to decide on a firm of reinforced

concrete specialists to carry out the work, or an engineer to design the work, and that, he considered, was something very useful gained.

"There are some difficulties in the way of carrying out the scheme, one of which is the difficulty that the reinforced concrete specialist or the engineer will have in preparing detailed drawings of reinforced concrete work in time to satisfy the client, and in time for the quantity surveyor to take off his necessary particulars, because the details of reinforced concrete are very considerable and necessitate a lot of arduous work on the part of the engineer, more so than is the case with steel-work construction, and where time is of value the only method of dealing with the reinforced concrete quantities is by the suggestion which Mr. Theobald has laboured through, doing a lump sum contract in which the bills of quantities form a schedule and the entire building is remeasured."

Mr. A. G. Cross, F.S.I. (Hon. Secretary, Quantity Surveyors' Association): There was one point he did not think had been sufficiently emphasised by the lecturer, and that was the advantage which accrued to the building owner from the employment of the quantity surveyor. After all, it was the building owner who provided employment for the architect, the engineer, and the quantity surveyor, and his interests should be their first consideration.

"An inestimable advantage accrues to the builder from the employment of the quantity surveyor; and the quantity surveyor once being employed, it is his duty to see that quantities for every item embraced in the building or engineering structure upon which he may be engaged are provided. By no other means can the value of artificers' work be accurately estimated—in fact, the surveyor's opinion upon any question of value is usually worthless until the quantities are prepared for the particular building. There is nothing in either the workmanship or the materials of a reinforced concrete structure which, from its nature, cannot be measured and its value estimated by the surveyor's usual method of picking a complicated building to pieces and measuring each item of which it is constructed.

"Further, the provision of a bill of quantities usually results in a lower estimate being obtained. This in itself is of advantage to the building owner."

Mr. S. Bylander, M.C.I. (Chairman of Council, Junior Institution of Engineers), advocated a system of simplicity as regards taking out quantities. He suggested forming a standard, and it occurred to him that a very simple way was unit prices or unit quantities, and that it could be adopted with advantage. For instance, so many square feet of floor at certain thicknesses, and so many foot run of beams of certain sizes. The quantities might also state the weight of steel per foot run instead of the total weight of steel. Further, the number of bends per ton of steel might be stated, as well as the size of the bars. It was very convenient for contractors to price a bill of quantities which contained as few items as possible; still, the different items should be separated so that they could be properly priced.

With regard to separating the items for different floors, he did not think this necessary, perhaps, for an ordinary sized building, but it was very usful to have the different quantities.

Mr. T. B. Bare (V.-P. Quantity Surveyors' Assn.) thought everybody would be better off by the employment of quantity surveyors in ascertaining the value of reinforced concrete work. One chief difficulty seemed to him to be the question of steel, and with regard to steel, and perhaps to steel only, he suggested that provisional quantities be calculated from the constants of steel, and there would then be no difficulty with regard to the detailed drawings not being prepared in time. He thought a fair estimate of the amount of steel that would be required could be arrived at in that way.

Mr W. G. Perkins (District Surveyor for Holborn; Member of Council, Concrete Institute) did not think that constants could be used in the way suggested by Mr. Bare.

He agreed with a good deal of what Mr. Alban Scott had said as to the specialist, although he did not go quite as far as he did. He thought that the architect should learn a little about reinforced concrete. He should be able to design his floors, his beams, and his stanchions in such a way that he would be able to show on his drawings approximately the number of bars, their arrangement, and their diameter, the amount of reinforcement to take diagonal tension, etc. The quantity surveyor is then able to measure it and put it into his bill. That would give the builder something to price, and it would give a basis upon which to measure extras and omissions.

Turning to the question of measurement, the centering of floors should be dealt with in a little more detail than Mr. Theobald suggested, but sketches and sections showing the various sweeps and bends should be added to the bills of quantities. Further, the steel which obtained in helical or other curved reinforcements should be kept separately from the straight.

Mr. R M. Kearns quite agreed with Mr. Theobald in advocating that quantity surveyors should prepare the bills of quantities for reinforced work, but it seemed to be generally understood that the patentees of the different systems insisted on the use of quantities prepared by their own experts. This, for various reasons, was not a satisfactory state of things, and it was

highly probable that the client would obtain closer and more favourable estimates from contractors if they were supplied with bills of quantities which would give them a reasonably accurate idea of the work required to be done under the terms of the contract.

The matter was one of deep interest to quantity surveyors, for it was evident that the employment of reinforced concrete was rapidly increasing.

With reference to the items proposed to be inserted in bills of quantities, he did not agree with Mr. Theobald on every point. Labour items should be discarded as much as possible. They were likely to be over-priced so far as the centering was concerned, the latter to a large extent being only chargeable as "use and waste." It was not customary to measure the labour on centering in connection with the stonework in Gothic window and door openings.

All the concrete walls and floors should be supered, keeping each floor separate. The concrete in beams and piers might be cubed.

The centering to walls and floors should be measured over all surfaces and billed at per square or foot super. The casing to beams and piers, cornices, jambs, etc., might with advantage be measured at per foot run, stating the girth and giving a figured section in the margin of the bill showing any angle fillets or splay cutting.

With reference to the reinforcement itself, the whole of the steel bars, loops, stirrups, or ties should be weighted and billed at per cwt. There should be no numbered items. When wire is used for binding it need not be measured, but should be mentioned. In short, the price quoted per cwt. for the reinforcement should cover the whole of the smiths' materials and labour.

Mr. W. B. Davis (M. Quantity Surveyors' Association), after dealing with Mr. Alban Scott's remarks and some general references to quantity surveyors, said, with regard to the centering, there was one point which offered difficulty, and that was the re-use of centering. For example, take a warehouse with, perhaps, five or six floors; it made a very great difference to the cost of the centering as to the number of times it could be re-used on the same building without a large allowance for waste.

Mr. George Corderoy, Assoc.Inst.C.E., F.S.I., M.C.I.: "The difficulty which is experienced in taking out quantities for reinforced concrete work really resolves itself into this, that the system of reinforcement to be pursued has so seldom been settled before the tenders have been invited. The practice which has largely prevailed hitherto has been to invite the estimates for various systems of reinforced concrete for the same building or for the same structure.

"In dealing rather extensively with reinforced concrete work in different forms—monumental buildings, warehouses, jetties and wharves, etc.—at any rate in the present state of knowledge and in the present welter of systems—it does not seem possible to lay down any absolute method of measurement, as the methods of measurement must necessarily vary according to the nature of the building to be erected."

Mr. W. R. Hood, F.S.I. (M. Quantity Surveyors' Assn.), said: "Speaking from personal experience, detailed quantities should be taken out for special work, for which, up to recent times perhaps, large sums—provisional sums—have been put into the bills of quantities. In reinforced concrete work the same would have to be done as has hitherto been the case with iron constructional work.

"The subject of the paper that Mr. Theobald has read will certainly lead to considerable discussion in the future in another place—in fact, in two places; for surely the Surveyors' Institution should feel it incumbent upon them to call a meeting of their own members and the Quantity Surveyors' Association and, with the assistance of the reinforced concrete specialists, formulate a system of measurements which will be generally adopted.

"There is, undoubtedly, an element of speculation in the present system. If a specialist is invited to give an estimate for a particular system of reinforced concrete work, he naturally takes out the quantities in such a way as to cover him for any contingencies that take place, and therefore the estimate that he produces is not an accurate estimate of the work that has to be carried out. There are variations in the general drawings and the detailed drawings, after the quantities have been prepared by the specialist, and those variations, if not adjusted, undoubtedly benefit the reinforced concrete specialist, not the building owner."

The President showed a method which he had adopted for several years in taking out quantities, and, as a rule, the original quantities can be taken if they were asked for at any time, and every measurement checked from start to finish.

Taking, as an example, one thing only—a column—and assuming, for the sake of argument, that the base being dealt with inclined at an angle of 45 degrees. In taking out quantities, this is the method he adopted. Paper that is specially ruled divided up in five columns [illustrating on blackboard]. For the sake of argument, let the first column repre-

sent concrete, the next represent shuttering, the third represent steel, the fourth represent the abstract or the analysis—this is the rate column—and the last is the total in pounds, shillings, and pence; thus giving every detail of the quantities from start to finish. It is not a case here of taking out quantities all over the place, then starting afterwards and abstracting them—and that is where so many mistakes are made.

Taking the first item—concrete. Give its area by its thickness and reduce it down to cubic feet.

Dealing with the next column—the measurement for shuttering [illustrating]. Now, if the angle is 33 degrees, shuttering for that base is not required, as the concrete will stand up, but if it is to be 45 degrees the concrete will not stand up; therefore it becomes necessary to put a subheading under "shuttering," for the simple reason that the extra cost of making the shuttering on the splay is caused by the cutting of the angles and the holding of the whole together.

The steel column shows the whole of the steel—sizes of bars, their lengths, their weights, and also the shear members. This gives the weight of the steel in the base.

This finishes the base of the column, with everything taken out—its concrete, its steel, its shuttering, both plain and splayed. Then carry the totals into the abstract column, also if there are any labours; but, as a rule, in column bases they are absent. In taking out proper bills of quantities, this gives everything for the abstract without having to refer to back sheets.

Regarding the column shaft, the same method applies. First take the concrete, then the plain shuttering, the splayed shuttering under a separate heading; then take the steel in plain rods and any hooping or linking under separate headings, all of which is abstracted in the fourth column, as well as any extra labour, etc.

This same method can be applied to every description of work. If by any possible chance there was any circular work, it was taken as an extra foot super on the ordinary work. When it came to windows, the deductions should be made for the window area, and it should be stated in the quantities that everything was net, notwithstanding any trade custom to the contrary. He contended that this system, if followed out in its entirety from start to finish, made reinforced concrete quantities the easiest to take out of any work.

He recommended that all quantity surveyors should depart from their usual method of taking out quantities for this work.

ADJOURNED DISCUSSION.

The President, in continuation of his remarks of the previous week and in accordance with requests received by him as to the method he employed in taking out quantities for reinforced concrete work, had prepared a cartoon illustrative of his system. This cartoon simply represents the sheets that go out to a contractor when he applies to him to get out designs and quantities for the work. With the aid of the blackboard, the speaker then further amplified his remarks of the previous week. The method clearly indicates the necessity of separating out the different items, such as steel, shuttering, concrete, column work, etc.

He then called upon other members to continue the discussion.

Mr. R. W. Vawdrey, B.A. (Assoc.M.Inst.C.E.; Member of Council C.I.), said he was connected with a specialist firm, and entirely agreed with all that was contained in Mr. Theobald's paper. The whole position of the question of designing reinforced concrete work in competition as it exists at present is most unsatisfactory, due to a very great extent, he thought, to the absence of the regularised method of dealing with the matter that obtains in nearly all other classes of construction.

The great difficulty and the great amount of dissatisfaction which occurs in connection with the design of reinforced concrete work is owing to the fact that contractors are asked to tender not upon one set of designs or one set of quantities, but on many such designs, all differing from each other. It is that which induces the chief objection there is to the present system.

As regards the question of time, everybody who has had any experience with the question would agree with Mr. Theobald that the specialists concerned—that is, those firms who make it their business to design in reinforced concrete—will welcome with open arms the introduction of the quantity surveyor. As is pointed out in the paper, the employment of a quantity surveyor merely relieves the concrete specialists of a great deal of elaborate work for which they are not so well fitted as a quantity surveyor, and, of course, it relieves them also of the responsibility.

As regards a separation order, this is a very good point, and has been elaborated by the President in his remarks. The more the quantities and the different portions of the structure—the fittings, columns, beams, etc.—are separated, undoubtedly the clearer and the cheaper it is.

After dealing with the discussion at some length, the speaker stated in conclusion that he thought it was generally admitted that the present condition of tendering for reinforced concrete work is very unsatisfactory. But he did not wish to say that the specialist firms are to blame in the matter. If all architects would only realise that the specialist firms exist for the purpose as a specialist firm of designers, things would be very much simplified. At present, in the great majority of cases, architects or quantity surveyors acting for their clients almost invariably ask the specialist firms to submit tenders. That is, of course, absolutely incorrect. The specialist firm does not, except in a very few instances, submit tenders. The specialist firm is a firm whose existence is for the purpose of designing reinforced concrete work.

Mr. Frederick Hingston (M. Quantity Surveyors' Assn.) : There are one or two more points to be mentioned with regard to the taking out of quantities for reinforced concrete work. First, with regard to the concrete work itself, the speaker said he did not agree that small rods should be taken, unless they are very numerous.

As regards the centering, this should be given at per foot run, giving the sizes of the beams where possible. Of course, where the sizes differ very considerably they might be averaged. Shuttering should include the triangular fillets and any labours upon them. As regards the larger steel work, the labours on them should be taken and the whole of the steel work should be kept separated under its different sizes.

There was one other point not mentioned by the lecturer, and that was the finishing of the concrete. He assumed the lecturer would take that separately and treat it very much as the quantity surveyors do—namely, the plaster or similar finishing on the inside and whatever facing is on the outside.

Mr. G. C. Workman, M.S.E. (Member of Council, Concrete Inst.), speaking from the point of view of an engineering designer working under a patented system, ventured to make the following remarks :

First of all, he was very pleased to see that Mr. Theobald states quite clearly that he is making no reflection upon the quantities supplied by the engineers under the present system, and that his criticism is solely directed against the actual method of dealing with reinforced concrete work, and not against its exponents. As a matter of fact, the reinforced concrete engineers are directed by circumstances over which they have very little control, and they would in many cases welcome the help of a quantity surveyor. He personally had endeavoured for many years to bring about a collaboration between the reinforced concrete specialist, the architect and the surveyor. Unfortunately, the engineering designers are depending upon the requirements of their clients, and competition prevents each individual firm of engineers from attempting to dictate the proper course which the client ought to follow for the mutual benefit of all concerned.

Regarding the lecturer's remarks as to the correctness of the quantities not being guaranteed, the speaker stated that most of the firms of engineering designers working on similar lines to his—the Coignet system—must guarantee the accuracy of the quantities, or at least of the unit quantities of concrete, steel and centering for each element of the construction. It is evident that, under these circumstances, taking into account the fact that the work must be done in many cases with extraordinary rapidity, there is a considerable amount of risk. The point is, assuming that surveyors would be willing to take out the quantities very rapidly of a large number of competitive schemes throughout the year, would they be prepared to take the financial responsibility for the accuracy of their quantities, and also to do this on the understanding that they would not receive any remuneration whatever for all those schemes which the firm of engineers in collaboration with whom they were working were not successful in securing?

Before anything practical can be done in the direction suggested by Mr. Theobald, it will first be necessary that quantity surveyors should make an exhaustive study of the various systems which are at present continually in competition for works in reinforced concrete, and also that they should solve the question as to whether or not they are prepared to work in collaboration with the designers, on the same speculative terms as the latter are compelled to adopt on account of the fact that they see no other alternative.

Mr. Theobald states that the methods of the modern quantity surveyors are the outcome of the knowledge of three or four generations who have had constant practice in this profession. Unfortunately, the quantities for reinforced concrete are quite different from anything to which surveyors are accustomed, so that the experience of all their ancestors will be of very little avail to them. In fact, unless a quantity surveyor has a perfect knowledge of the particular system of reinforced concrete for which he has time to take out quantities, he is far less capable of doing this work properly and rapidly than the specialist engineer.

In conclusion, the entire question concerning the employment of quantity surveyors in

conjunction with reinforced concrete chiefly depends on whether or not the quantity surveyors are willing to take the same responsibilities and run the same risks as the specialist engineer.

Mr. Moritz Kahn, M.C.I., thought Mr. Theobald has the honour of having presented one of the most interesting papers that has been read before the Institute.

He, too, hoped that sooner or later the quantity surveyor will take an active part in the measurements of reinforced concrete work.

The preparation of quantities for reinforced concrete work is probably more intricate than the preparation of other quantities. Each designer has his own method of detailing the work. These methods differ to a considerable extent, and standards which might be drawn up for one designer will not apply to the other. The measuring of the concrete and steel in the respective items is a simple matter, and under ordinary circumstances the measuring of centering is a simple matter; but the ordinary circumstance is not the rule, with the result that, speaking offhandedly, it is a difficult matter to generalise a method of measuring quantities of centering. It seems that satisfactory results can be obtained by giving the contractor general measurements of the centering and submitting with the measurements such drawings as will enable him to understand the nature of the work he will be called upon to perform. After carefully studying such drawings, his experience ought to teach him how to price the centering.

The present method adopted by the specialist is one which has been forced upon him by circumstances over which he has no control.

Mr. Percival M. Fraser: As a quantity surveyor he took exception to a few remarks that Mr. Theobald had made. He did not think there is one client in a thousand who ever sees the bills of quantities, and a client would not pursue them with any great gratification.

Regarding the lecturer's remarks as to the procedure adopted by the architect deciding to construct a reinforced concrete building, he thought this was quite wrong. He saddles an architect with this somewhat undesirable method of carrying out a concrete building. He might have included engineers. Architects do not adopt this method. The concrete specialists themselves are beginning to freely state that they think the spirit of competition is very iniquitous. Every day seems to show a falling off in the desire of architects to have their concrete schemes prepared in a spirit of vulgar and elbowing competition. In regard to the specialist's approximate estimate, it can be done by special request; but surely it is not the common practice that Mr. Theobald states it is. With regard to the quantities supplied by specialists, this is absolutely universal. The specialist should, however, absolutely refrain from giving quantities unless he is prepared to give them by employing quantity surveyors trained up in the office.

Mr. Theobald, in quoting the forms of contract, might also have included the R.I.B.A. form, which is admitted by lawyers to be one of the finest forms of contract extant, applying to any business or trade; and he might have stated—which is of vital interest—that this R.I.B.A. form is issued under two headings, one where quantities form part of the contract and one where they do not form part of the contract.

There is also another form of contract which has been omitted—a very important one largely used for alterations—prime cost plus profit. It is a highly complicated form, but in many cases it is exceedingly valuable, and it should have been mentioned in an authoritative paper of this sort.

The whole trend of this paper is, and quite rightly, a plea for the employment of quantity surveyors.

MR. THEOBALD'S REPLY.

Mr. John M. Theobald, F.S.I., M.C.I., said his paper had been rather under a misapprehension. He certainly meant it as a justification for the employment of the quantity surveyor and only very little of it was on the methods of measurement. Most of the speakers have dealt at length with the methods of measurement, and consequently the greater part of the paper, except by one or two speakers, has not been touched upon.

The general consensus of opinion seemed to be that No. 4 form of contract was the most practical outcome of the methods of measuring reinforced concrete work. That is the ancient schedule of subsequent measurement.

Then, dealing with Mr. Bare's criticism in regard to the question of steel work, of course, in initial quantities, he admitted it was necessary to ask the weight per foot from the specialist. If the contracts are not prepared they cannot be put in by any other method.

With regard to Mr. Kearns' criticism and his suggestion of measuring beams per foot round, he could not quite agree. He thought Mr. Kearns a little inconsistent because he pleads for a shorter bill of quantities, and then running all the beams in various sections. That would make a very long bill. He did not think it mattered very much if the depths are the same and only the widths are averaged, but he did think the superficial method was the better

way of dealing with it. In regard to Mr. Kearns' suggestion that all the concrete walls and floors should be included in the superficial, he did not see that it could be done.

Mr. Davis's point as to the rules of centering for concrete is one which he was afraid quantity surveyors could not deal with. They must measure the entire amount of centering and leave it to the contractor to make such reduction in the price he thinks necessary.

Mr. Workman wanted to know whether quantity surveyors would be prepared to deal with quantities under the circumstances that he mentioned. The answer is in the negative.

In regard to Mr. Fraser's remarks about the question of clients seeing bills of quantities, it was the variation account he (the lecturer) referred to.

Regarding the two forms of contract omitted, they should, of course, have been mentioned.

Then, as to the question of net measurement, that is a direct contractor's question. It is the very last item; but what is intended by net measurement is this: in the rough and ready, quantities have to be prepared in a rush at the present day by competition. For instance, the stanchions would go right through the floor, and then the floor would not be deducted for the passing of the stanchions. That is the sort of thing meant by net measurement, and it is understood by contractors.

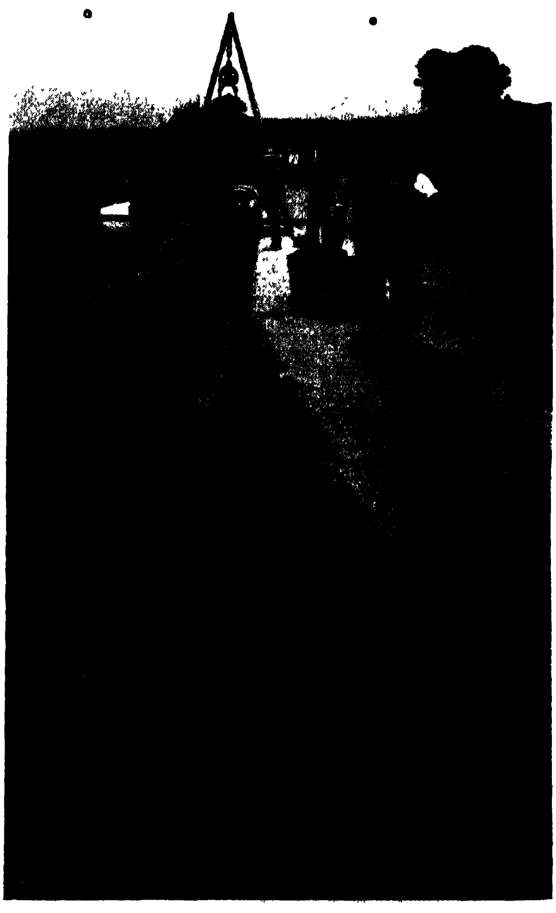
NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

A REINFORCED CONCRETE RISING MAIN.

THE accompanying illustrations show a rising main in reinforced concrete at Luton, Bedfordshire. This main is about one mile long, and has an internal diameter of about 27 in. The skin thickness of the concrete is 3 in., and the steel reinforcement is 2½ per cent. of the volume of concrete. The pipe has no lining of any kind, and according to a test made by the borough engineer of Luton, the pipe after having stood full for 12 hours lost such a small quantity of water that he considered the same to be perfectly watertight, especially bearing in mind that the valve which closed the bottom end of the main could not be seen and might not have been absolutely watertight. The pipe also underwent a test of 60 lbs. pressure per sq. in. continuously for six months on the contractors' premises before delivery. The work was carried out under the supervision of the borough engineer, Mr. J. W. Tomlinson, M.Inst.C.E.; and the contractors were the British Improved Construction Co., Ltd.



A REINFORCED CONCRETE RISING MAIN AT LUTON.

A REINFORCED CONCRETE INCINERATOR.

The Incinerator measures 2 ft. 9 in. by 2 ft. 9 in. inside, and the height from the firebars to the bottom of the feed door is 2 ft.

The whole, with the exception of the doors, firebars, and top of flue, is made of reinforced concrete. The walls are 4 in. thick, and the flue and arch are 3 in. thick.

The concrete is 1 Portland cement, 2 sand graded, 4 stone ballast up to ½ in. Each side is moulded separately, the back, side, and bottom of flue being moulded in one. The reinforcement

consists of two layers of ½ in. wire netting, 1½ in. from the face inside and ½ in. from the face outside. For the reinforcements across opening ¼ in. round bars are used. In the back piece ¼ in. round bars are run up into the front of the flue, the sides of

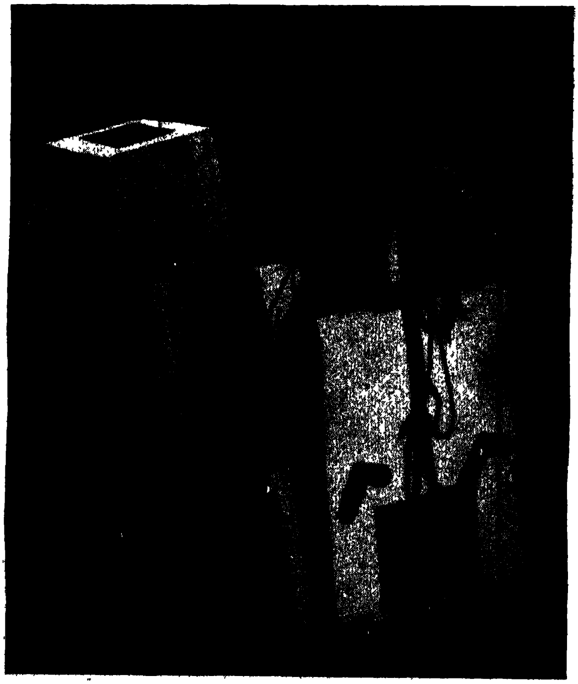
Showing Main under Test.
A Reinforced Concrete Rising Main at Luton.

the flue having diagonal ¼ in. round bars securely fastened to the bars in the back piece of the chamber and to other bars in the back side of the flue.

In the arch, which is moulded on the centering, wires are run across along the course of the arch from the rods left projecting in the side pieces, and ¼ in. rods from the front to the back pieces.

The various sides are moulded at site, with steel feet, which are embedded in lime concrete. When the sides are in position the projecting portions of the wire netting are tightly interlaced and the corners filled in with concrete.

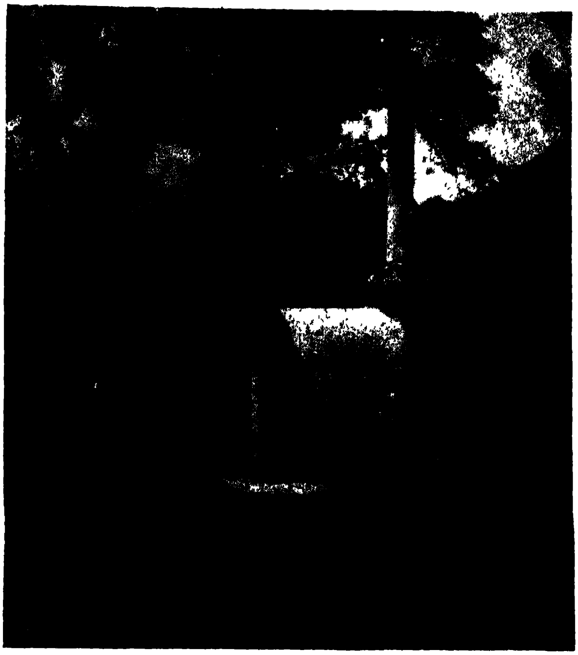
The arch is then moulded on centering. The firebars are made up in three sections, which are removable for repairs, and which rest on steel lugs moulded into the sides. The upper of the two doors shown in the flue is for a grass filter for the smoke. Dry grass is put on wire netting which extends across the flue, and this catches most of the oily substance in the smoke which gives it its unpleasant smell. These particulars and illustrations were placed at our disposal by a correspondent in India, Captain P. N. Kealy, R.E.



A Reinforced Concrete Incinerator in India in Course of Construction.

A REINFORCED CONCRETE RETAINING WALL.

Our illustration shows a new reinforced concrete retaining wall recently erected at Basford, in Staffordshire, in place of an existing one which had shown signs of failure in different places.



Completed Structure.
A Reinforced Concrete Incinerator in India

As considerable improvements are to be effected in this locality in the future, the new reinforced concrete wall was designed to carry all the pressure that was ever likely to come upon it, and that part of the wall shown under construction in the illustration attains a maximum height of 20 ft. above future ground level.

It was essential that the high-level road should be interfered with as little as possible. Buttresses were, therefore, out of the question, and a cantilever wall was adopted with a base projecting under the low-level road, about 2 ft. beneath future road level.

The work was carried out under the instructions and superintendence of the borough engineer of Stoke-on-Trent, Mr. A. Burton, Assoc.M.Inst.C.E., to the designs of the Indented Bar and Concrete Engineering Co., Ltd. The contractors were Messrs. F. Barke & Son, of Stoke-on-Trent.

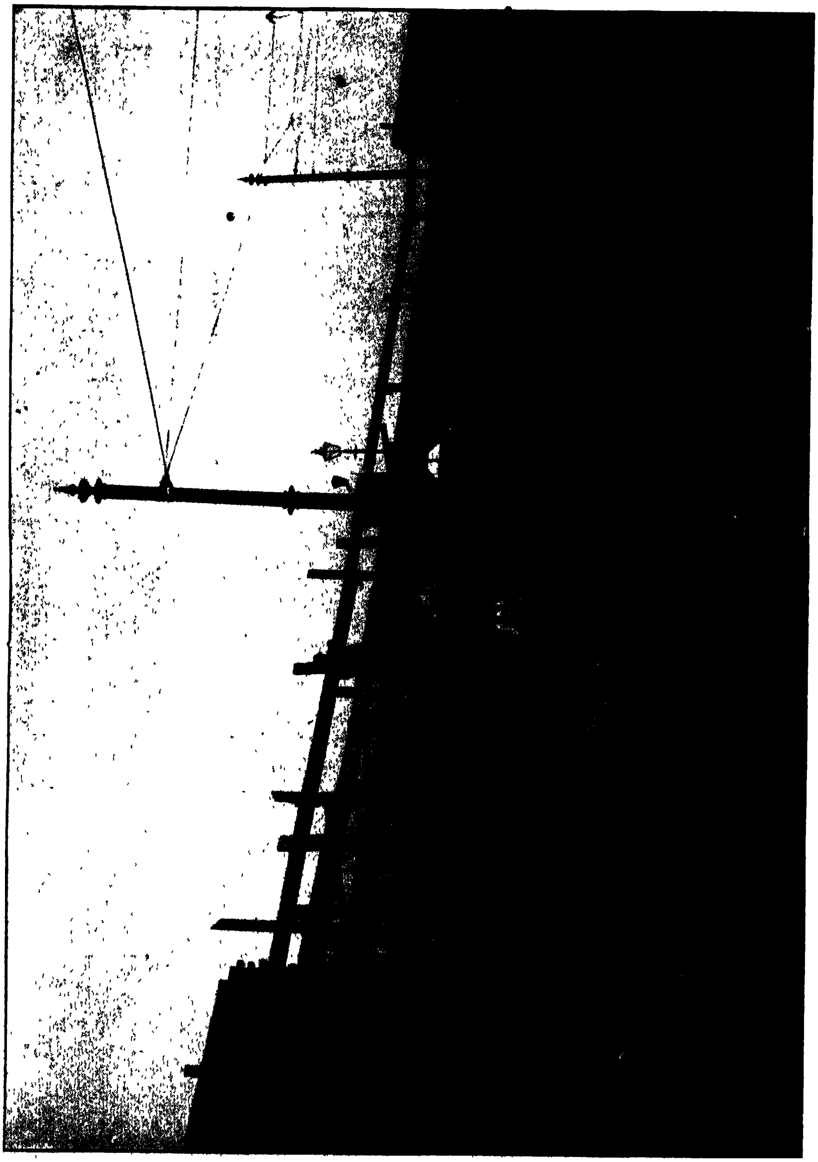
A REINFORCED CONCRETE TANK AT A CURRENT METER RATING STATION AT CALGARY, ALBERTA, CANADA.

We present herewith some particulars of a reinforced concrete tank, forming part of a current meter rating station at Calgary, Alberta.

In designing the work for this station the aim was to gain the most perfect apparatus possible for rating the current meters and to create a permanent structure, so that it was early decided to use concrete in the construction of the necessary tank.

As no stretch of still water having a suitable length and depth was available, it was necessary to create a tank, and in studying its design two points had to be principally considered. First, as the water supply had to be taken from the city mains, the tank had to be made proof against any leakage. Secondly, the cross-sectional water area was required as small as possible and yet of sufficient dimensions to guard against any following on movement of the water, in running the meters through the tank. To overcome the first difficulty a heavily reinforced structure was designed, such that being emptied and exposed to the weather in winter no temperature cracks could develop, and the inside faces of the tank were water-proofed by Sylvester's process. In deciding on the proper cross-section of the tank to overcome the second difficulty no data were obtainable, but with the tank as constructed no following on movement or undue disturbance of the water has been observed even with the largest meters tested at velocities as high as 10 ft. per second. The length of the tank (250 ft.) was adopted in order to bring the cost of the structure within the limits of the amount of money available, but provision has been made in locating the tank for its future extension to a length of 500 ft, which is desirable in order to attain the highest degree of accuracy.

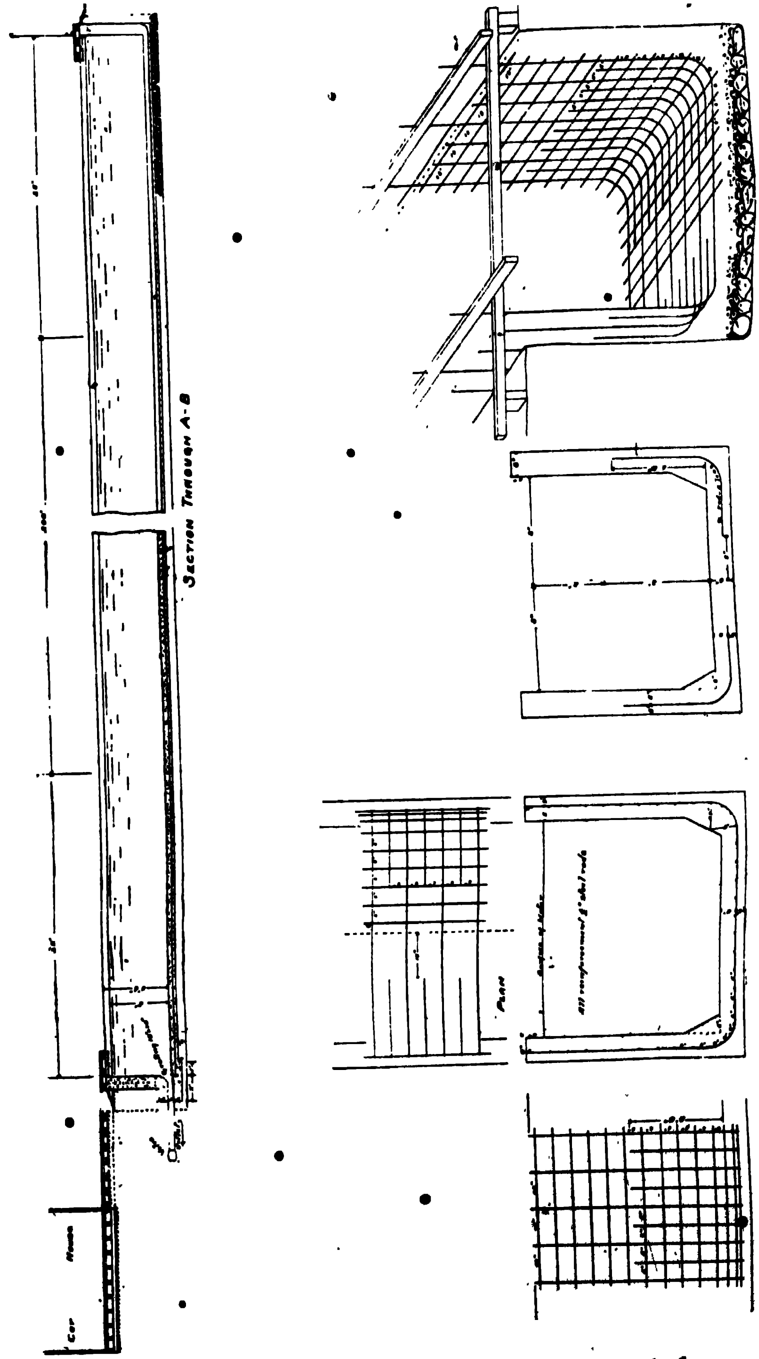
The concrete tank is 250 ft. long with an inside width and depth of 6 ft. by 5 ft. 6 in., and the depth of water to be maintained is 5 ft. The floor and walls are 8 in. thick and are reinforced heavily, longitudinally and transversely, with ½-in. round mild steel rods, in order to absolutely preclude any temperature cracks in the concrete.



A Reinforced Concrete Retaining Wall at Basford, Staffs.

The concrete was specified a mixture of one part Portland cement to seven parts clean river gravel, to have at least fifteen turns in a good machine, and to be placed wet and thoroughly tamped. All the interior faces were thoroughly spaded in order to create a smooth close-grained surface, to which to apply the Sylvester's wash. All steel rods

at joints were overlapped 16 in., and it was specified that they were to be wired so as

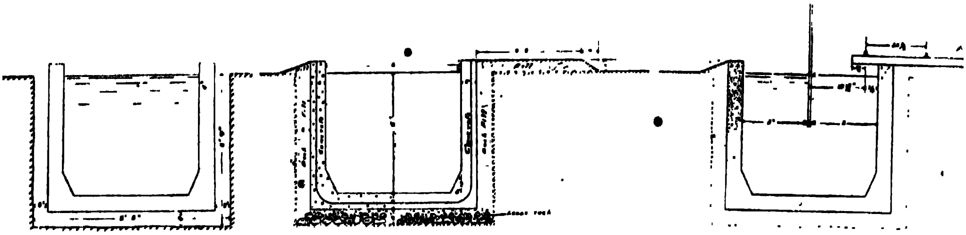


Sections. Elevation.

REINFORCED CONCRETE TANK FOR CURRENT METER RATING STATION, CALGARY, ALBERTA, CANADA.

to have contact throughout the whole of this length. The tank floor was laid on an

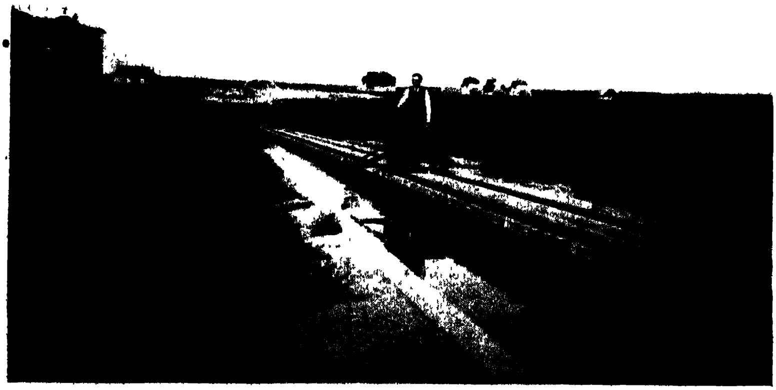
8-in. foundation of large stones overlaid with smaller stones and gravel, in order to provide thorough drainage for any water which might leak through the tank, so that when the tank is emptied in winter and exposed to the weather no heaving might result from any water being lodged under the tank bottom. The soil beneath is of sandy character, which is permeable to water. The water supply is from a 2-in. iron pipe laid from the city mains, and a 6-in. tile drain 224 ft. long, fitted with an iron gate valve at the tank, allows the tank to be emptied at any time into the river. After



Section showing excavation — Section C-D, Platform removed — Section E-F

Reinforced Concrete Tank for Current Meter Rating Station.

the tank was completed all the inside faces were treated with two coats of Sylvester's wash. Up to the present the tank has been twice exposed empty to severe cold with the thermometer at —30°, and no cracking of the concrete whatsoever has resulted, except a few hair-line cracks near the top of the walls. As regards the water-proofing, two observation shafts were left along the tank sides running down to the foundation, and no leakage whatever was observed during the summer when the tank was full, except a slight dampness at the bottom of the side walls. It should be noted that



General View.

Reinforced Concrete Tank for Current Meter Rating Station.

another reason why it was desired to make the tank leak-proof is that it is intended to obtain evaporation records at the tank in future seasons.

This work was carried out for the Irrigation Office, Department of Interior, Alberta, Canada, under the supervision of the Chief Engineer, Mr. F. H. Peters, A.M.Can.Soc.C.E., to whom we are indebted for our illustrations and particulars.

A HOUSE OF CONCRETE BRICKS.

Our two illustrations show the back and front view of a house erected in Hove, near Brighton, in concrete bricks. Red concrete facing bricks have been used up to the first floor and for the chimneys. The proportion of mixture was seven parts sea sand to one part cement. Natural concrete bricks were used for the rough cast part.

These bricks consisted of four parts sea sand, four parts coke breeze, and one part cement. The bricks used were those made on the machines of Messrs. R. H. Baumgarten, of Lewisham, S.E.

Back View.

Front View.

CONCRETE BRICK HOUSE, HOVE, NEAR BRIGHTON.

CORRESPONDENCE.

Under this heading we invite correspondence.

Below we print a letter relating to the London County Council's administration of the London Building Amendment Act, 1905. We, like several other technical journals, have received this communication, which sets out the approximate number of existing buildings requiring attention, the causes to which the present state of affairs may be attributed, and some suggestions as to how the existing dangers may be remedied.

We referred to the subject editorially in our previous issue, and in the current number we have also accorded an editorial notice to this matter.

Our columns are open to those who desire to criticise figures given, to those who wish to reply to the indictment, or desire to comment upon the suggestions made.—ED.

FIRE PROTECTION AND THE LONDON COUNTY COUNCIL.

How the Council's Existing Powers could be enforced without undue expense or delay.

SIR,—A full month has elapsed since the fatal Kensington fire.

One would have thought the London County Council would have been most anxious to prevent the repetition of such loss of life occurring again in the many existing buildings of a similar character.

But both in the Council Chamber and in the Press the Chairman of the Building Act Committee of the Council appears only to be anxious to find excuses for its lack of activity in administering the Building Acts (Amendment) Act of 1905, by giving entirely non-relevant information as to the supervision of buildings about to be erected —as distinct from *existing buildings*—the number of inspections made under the Factory Acts, etc., *i.e.*, useful, but entirely extraneous activities of his Department. His aim also seems to be to belittle the number of existing buildings requiring the attention of the Council, while on the other hand, exaggerating the difficulty of the character of the work that has to be done.

Regarding the figures that I have put forward from time to time in the Press and elsewhere, as to the number of existing buildings requiring attention and the very small proportion of these buildings that have been put in order during the past seven years, the London County Council has not been able to contradict those figures, or put up any other pertinent ones in their place, and I would thus now summarise my data once more as indicating the Council's extraordinary lack of energy in providing for the safety of the public.

My figures, to summarise, are as follows:—

(i) There have been 48,566 cases notified by the District Surveyors to the Council under Sections 10 to 12 of the 1905 enactment as requiring the Council's attention. Of these only 351 cases have been put in order so as to comply with Section 11, and only 4,430 cases have either been exempted, or ordered to be improved under Sections 10 and 12 of the Act. The balance that remains and awaits attention is thus close on 44,000 cases.

(ii) There are further well over 50,000 buildings awaiting attention under Section 9 of the Act, and of these only 527 have been put in order in the past seven years (*i.e.*, up to June 12th last), together with, say, an additional 100 up to date. In other words, over 49,000 buildings are still awaiting attention under this Clause.

Bluntly, this means that there are to-day between 93,000 and 94,000 existing buildings which have been awaiting for seven years the Council's pleasure, and the majority of these buildings might have been put in order by this time without any very great effort on the London County Council's part.

Now without touching on questions of hidden policy or municipal politics, the known causes for this state of affairs comprise the following:—

(1) A lack of co-operation and mutual confidence between the Council and the building owners.

(2) A lack of co-operation between the Council and the 50 statutory District Surveyors—who are not actually their employees—and a certain amount of interference on the part of the Council in the District Surveyor's work.

(3) An absence of all energy or earnest in the matter on the part of the Council

per se as distinct from their technical officers—*i.e.*, their Superintending Architect, Assistant Architect, and Committee Clerk, all men of exceptional ability and high purpose.

(4) A lack of industry and *savoir faire* on the one hand, and much "woodenness" on the other, in the Council's Building Act Committee.

(5) An extraordinary undermanning of the Building Act Department, having regard to the work that it should attend to, and particularly an insufficient number of suitably paid managing assistants—*i.e.*, Deputy Assistant Architects.

(6) A general public impression—fostered either purposely or unwittingly by the Council—that the Act is a "dead letter."

It is, however, no use complaining of the County Council's failings without indicating some practical and economic remedy useful alike to building owner and public authority. This remedy, to my mind, is a very simple one, and comprises the following:—

(*a*) A public announcement in the Press (to be repeated monthly) that it intends to have the whole of the work under the Building Acts (Amendment) Act of 1905 remedied by January 1st, 1918, the public announcement to be followed by two circular notices in the 44,000 notified cases under Sections 10 to 12.

(*b*) An immediate instruction to the District Surveyors to notify to the Council, say within six months (as set out in Section 17) all cases they consider to come under Section 9—a matter that has been practically neglected during the past seven years—and immediately upon receipt of these notifications an issue of two circular notices to owners concerned that the Council are prepared to receive suggestions accompanied by plans with proposals as to convenient dates for carrying out the necessary structural improvements, and are prepared to assist in every possible way applicants who volunteer plans and offer practical remedies. The circular notices should indicate certain primary principles desired by the Council, such as alternative routes of exit from workshops and dormitories.

(*c*) A cancellation of the existing embargo that the fifty District Surveyors are not to press the execution of work under Sections 10 to 12 in their respective districts, and in place of that embargo an instruction that they shall see that the whole of this work is carried out by 1918 or earlier, the instruction to set out certain guiding principles as to remedies and also grounds for exemption. As to exemptions, any recommendation for exemption signed by the local District Surveyor and two adjoining District Surveyors should be accepted *ipso facto* by the Building Act Committee as a *prima facie* case for exemption without further investigation or expense.

(*d*) The energetic enforcement in 1913 by legal proceedings of at least one notoriously bad case under Section 9 and one under Section 10 in each district as an earnest of the Council's intentions.

(*e*) The formation of several Sub-Committees of three in the Building Act Committee to sit weekly to accelerate the decisions requiring the Committee's attention under the 1905 Act, with the necessary strengthening of the Superintending Architect's personal staff and the staff of the Committee Clerk.

(*f*) The immediate strengthening of the "Escape" branch in the Building Act Department by five managing assistants, twenty senior assistants, twenty junior assistants, and twenty clerks, etc., all on the temporary establishment, the staff to work by areas, and each senior assistant to follow his own case from beginning to end, all modern mechanical equipment and facilities to be used to accelerate the work, including photography and mechanical copying instead of tracing.

(*g*) The publication quarterly of a list of building owners who have complied with the Building Acts (Amendment) Act of 1905 and the addresses of the buildings that have been put in order.

If the remedy be organised somewhat on these lines the Council will, in the first place, find that much of the necessary work will be done by owners ***voluntarily*** within the given time-limit at their own dates and in a manner convenient to themselves—*i.e.*, when doing their usual decorative and structural repairs. They will find a vast

number of the owners will submit their own plans and suggestions. The Council will be rid of much of the work under sects. 10 to 12, which the district surveyors are quite capable of handling, and they will find their intentions to carry through this somewhat unpleasant duty of enforcing the Act of 1905 in an equitable and businesslike way will be appreciated and met in a proper spirit by the majority of building owners and their professional advisers. As to the cost that falls upon the building owners, they have already had seven years' time to accumulate the necessary funds.

Given a procedure on these lines, the necessary alterations to existing buildings *can be readily completed in five years,* and the structural work will not be found to inconvenience the metropolis, as it is mainly internal and less in quantity than what has been done in London in several active building periods of lesser duration.

There is, I feel sure, little that is unreasonable in my proposals as to the remedy of the present grave scandal of unnecessary danger from fire, and I thus trust that what I suggest, or something equivalent, will be promptly carried into effect in the interests of the community.

I am, dear Sir,
Yours very truly,
EDWIN O. SACHS

Offices of the
BRITISH FIRE PREVENTION COMMITTEE,
8, Waterloo Place, London, S.W.,
December 11th, 1911.

NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

"Artistic Bridge Design." By H. G. Tyrell. Chicago: The Myron C. Clark Publishing Co. Price $3 net.

A handbook consisting mainly of small illustrations and comments. There are 242 figures and plates in the 287 pages.

Mr. Thomas Hastings, the well-known architect of New York, contributes an introductory chapter on the general problem of the architectural character of bridge design, with some special references to the design prepared by his firm for the new Manhattan Bridge. The author's chapter headings deal with the Importance of Bridges, Reasons for Art in Bridges, Standards of Art in Bridges, Causes for Lack of Art and Special Features of Bridges before Principles of Design are discussed, and the Consideration of Steel Structures, Cantilevers, Metal Arches, Suspension and Masonry Bridges follows and complete the index.

We venture to think that this order suggests that the relation between cause and effect—that is, between constructional cause and artistic effect—has not been sufficiently appreciated, and that the large and miscellaneous collection of small photographs and thumb-nail sketch elevations need fuller analysis and some elimination before the real "Causes for Lack of Art" in Bridge Design are laid bare. Mr. Tyrell, however, interestingly states his conclusions as follows:—

"The reasons for lack of beauty in American bridges are as follows:

1. Indifference of engineers and their lack of artistic training.
2. Competition and commercialism, resulting in use of contractors' plans.
3. Lack of co-operation from architects.
4. Absence of art standards for metal bridges.
5. Haste in construction.
6. Railroad bridges used as prototypes for others.
7. Legal and financial hindrances.
8. Inadequate material.
9. Unsuitable and unsymmetrical location.
10. Absence of State or Municipal supervision.

"The Standards of Art in Bridges" proposed by the author are generally free and sound, but, we fear, insufficient to guide the student, while No. 4 begs the whole question. They are:

1. Conformity with environment.
2. Economic use of material.
3. Exhibition of purpose and construction.
4. Pleasing outline and proportions.
5. Appropriate but limited use of ornament.

It is to be regretted that opinion in the universe has become so mixed on the simplest problems of design, through the multiplication of facilities for the economical reproduction of photographs and sketches, and that the expensive carefulness with which such an important subject should be treated has to be deemed luxurious; students therefore have, in many subjects similar to that treated in this book, as best they can, to digest a crowd of imperfectly illustrated examples on quite insufficient information and wrestle doubtfully with insecure conclusions.

This handbook will not advance the serious study needed, and for the English student will not replace the pamphlet containing Mr. Husband's paper on the "Æsthetic Treatment of Bridge Structures" read before the Institution of Civil Engineers in 1901 with the report of the important discussion in which some leading architects took part which ensued during two meetings. The æsthetically-minded engineer would, we fear, be too simple to withstand his clients' thirst for sensations, while the practically-inclined artistic critic would scarcely carry conviction of his sincerity to his audience. Bridge architecture remains still a test of natural characteristics; what we shall do next, who knows? Why not a simple concrete beam across the Thames? at once embodying all the primitive virtues of constructional efficiency and avoiding the pitfalls of art criticism.

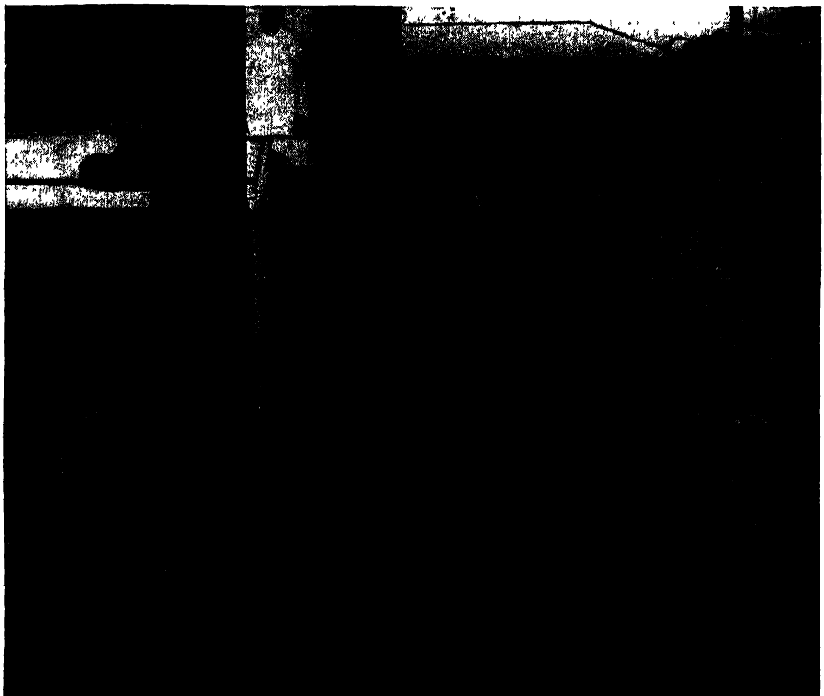
INDUSTRIAL NOTES.

These pages have been reserved for the presentation of articles and notes on proprietary materials or systems of construction put forward by firms interested in their application. With the advent of methods of construction requiring considerable skill in design and supervision, many firms nowadays command the services of specialists whose views merit most careful attention. In these columns such views will often be presented in favour of different specialities. They must be read as ex parte statements—with which this journal is in no way associated, either for or against—but we would commend them to our readers as arguments by parties who are as a rule thoroughly conversant with the particular industry with which they are associated.—ED.

TRIANGLE MESH CONCRETE REINFORCEMENT.

A FORM of reinforcement of American design has been brought to our notice by a recent report of the British Fire Prevention Committee, which report we reviewed in our last issue. It is a triangular wire mesh, and, though comparatively new to this country, is extensively used in America and other foreign countries. It is particularly applicable to slabs and partitions, but is also commonly employed for columns and pipes of large diameter.

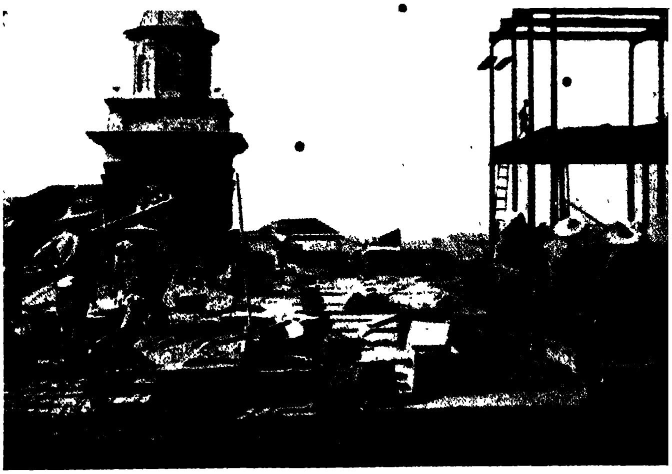
It is made of hard drawn cold steel wire with a tensile strength of 38 tons to the square inch and an elastic limit of 22 tons per square inch. There are no welds in any



ROBINSON & MUNDY'S BUILDING, RANGOON, BURMA.

part of the fabric, and the process of drawing eliminates the possibility of flaws. It is of a truss form of construction, which provides an excellent mechanical and adhesive bond in the concrete, and reinforces in every direction. The cross-wires assist the

longitudinal members in resisting the tensional stresses, thereby increasing the effective sectional area and enabling the engineer to use a lighter material for carrying a given load. Being of the hinged-joint construction, the fabric is flexible, and may be folded on any longitudinal member without bending the cross-wires; consequently it can be made to assume various conformations without producing any initial stresses. The difficulty of maintaining equal spacing of bars is entirely avoided, and the material can be laid by unskilled labour. It is supplied in continuous rolls up to 300 ft. long, so that no material is wasted by longitudinal laps; architects and engineers can therefore readily ensure that the amount of reinforcement they specify is actually installed.

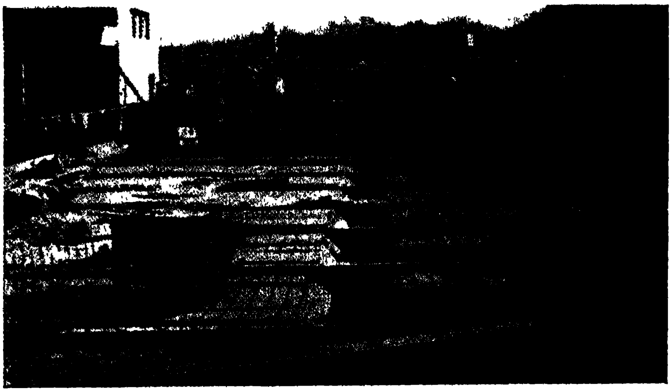


HONGKONG HOTEL, HONGKONG, CHINA.

As stated above, the material was submitted to the British Fire Prevention Committee on July 24th, 1912, and successfully passed their severest test, the calculated factor of safety being 3½. The following is an extract from their report:—

OBJECT OF TEST.

To record the effect of a fire of three hours' duration, the temperatures to reach 1,800° Fahr., but not to exceed 2,000° Fahr., followed by the application of water for five minutes, with a view to classification under "Full Protection" (Class B).



HONGKONG HOTEL, HONGKONG, CHINA.

Note.—The area of the floor under investigation was to be at least 200 ft. super. The floor was to be loaded with 280 lb. per square foot distributed.

The area of the floor in this case was 334 ft. super., divided into three equal reinforced concrete bays, supported by four rolled steel beams; the beams had a span of 15 ft., and the bays measured 15 ft. by 7 ft. 5 in. centre to centre; the floor was 5 in. thick, and the depth of the beams below the underside of the floor was 14 in.

The load was 280 lb. per square foot. The water was applied for five minutes from two branches.

Note.—The time allowed for drying was thirty-four days (summer). The centering was struck after twenty days.

SUMMARY OF EFFECT.

At the expiration of ten minutes the floor began to deflect, and continued to do so until the end of the test, when a maximum deflection of 4½ in. was registered.

On the application of water the concrete to the soffit of the beams, where struck by the jet, was knocked off, exposing the reinforcement, or wirework, under the beams.

The soffit of the floor was also eroded where struck by the jet, exposing the reinforcement.

On the load being removed the upper surface of the floor showed various cracks.

The permanent set of the floor over the beams was about ½ in., and the permanent set of the bays between the beams was about 2½ in.

Neither fire, smoke, nor water passed through the floor.

Classification "Full Protection" (Class B) was obtained.

As an auxiliary test the floor was allowed to cool and the load removed. It was then reloaded, on the centre bay only, with a load of 5 cwt. per square foot, this bay being strutted. The deflections recorded were as follows:—

	Beam.	Centre of Slab.	Beam.
Permanent set, July 31st, no load	0·6	2·4	0·4
Load of 5 cwt. per sq. ft., August 15th ...	1·9	4·1	1·7
Deflection due to additional load	1·3	1·7	1·3

The above readings were taken by a dumpy level. It will therefore be seen that the deflections of the slab itself, carrying a load of 5 cwt. per square foot, and after being subjected to the previous severe fire and load test, was only 1·7 minus 1·3=0·4 inches. This test, which we believe to be unique in this country, should prove interesting to those who are concerned with the safety of reinforced concrete buildings after having been subjected to a severe fire.

Similar tests to the above have also been made under the supervision of the officials of the Bureau of Buildings of New York City. In this case the ends of the beams were framed as they would actually be in a building of American design. The result of these tests showed less deflection than those recorded above. The makers strongly recommend, and apparently with some justification, the stiffening of the ends of all beams, and it would appear that English architects might follow out this practice to advantage.

The accompanying illustrations show this mesh as it was actually installed in a building in Rangoon, Burmah, and in the Hongkong Hotel, China. The latter shows the work being performed by coolie labour.

EDITORIAL MEMOS.

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POPULAR USES.

Under this heading it is proposed from time to time to present particulars of the more popular uses to which concrete and reinforced concrete can be put, as, for instance, in the construction of houses, cottages and farm buildings.—ED.

A MODEL FARMSTEAD AT BONSAUVEUR CONVENT, DUNGARVAN, IRELAND.

IN the present article we present some interesting particulars and illustrations of some new farm buildings of Winget Concrete blocks erected for the Bonsauveur Convent at Carriglea, Dungarvan, Ireland.

Some of the buildings shown here are of one storey and are built with 9-in. hollow concrete blocks, whereas the two-storey buildings, comprising stables, coach-house, laundry and steward's house, have the walls of the ground floor storey built on the cavity system with a 4½-in. outer leaf and 9-in. solid inner leaf, bonded together with

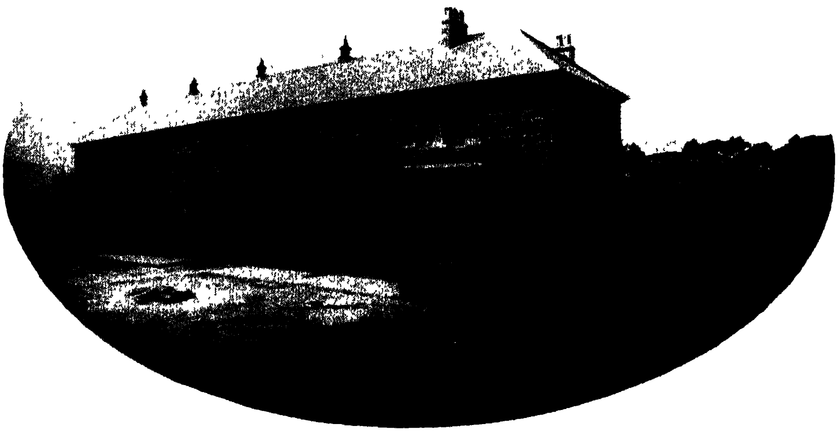


Fig. 1. Front Elevation, Main Building.

MODEL FARMSTEAD, BONSAUVEUR CONVENT, DUNGARVAN, IRELAND.

galvanized wall ties, the upper storey being built with 9-in. hollow concrete blocks. Breeze concrete slabs 2 in. thick form the internal partition walls and prove very effective, being light yet solid and occupy very little space. The aggregate for blocks was pit gravel passed through a ⅜-in. screen, mixed in the proportion of five of gravel to one of Portland cement. About 16,000 blocks were used in the erection of this model farmstead.

Our first illustration shows the front elevation to the main building with the principal entrance under the archway. This building contains the steward's house, coach-house, stables, and laundry, and measures 150 ft. by 30 ft. and 26 ft. to eaves.

Fig. 4 gives an excellent view of the fold-yard, showing the implement sheds, cow-house,

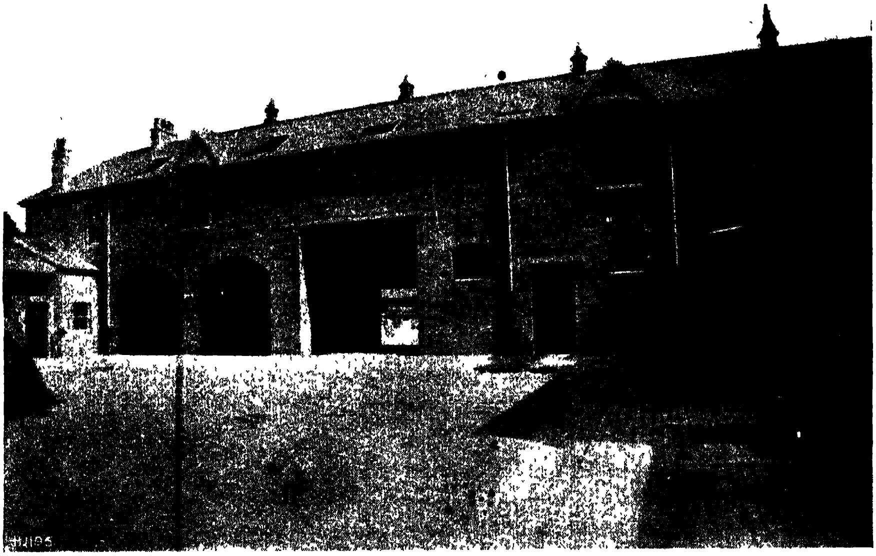


Fig. 2. Back of Main Building.

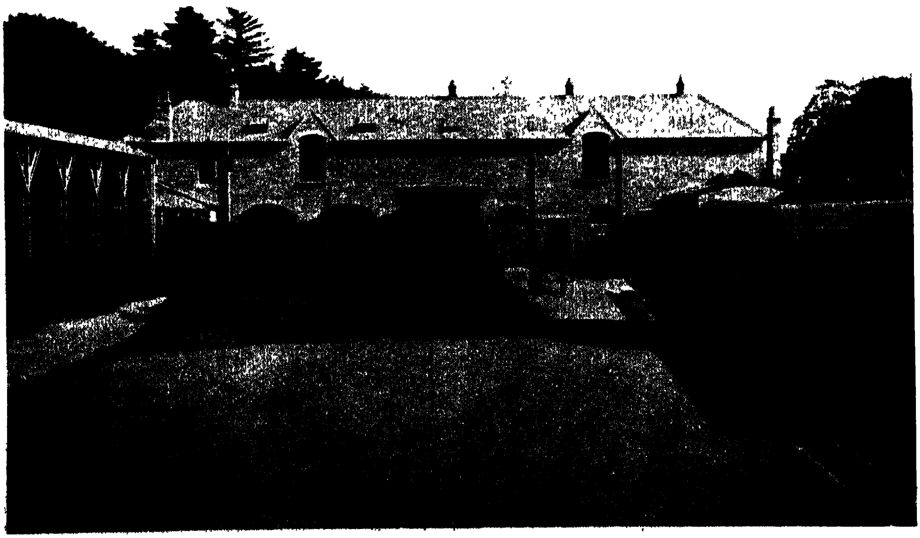


Fig. 3. Interior of Fold-Yard.

Model Farmstead, Bonsaúveur Convent, Dungarvan, Ireland.

Fig. 4. View of Fold-Yard, showing Implement Shed, etc.

MODEL FARMSTEAD, BONSAUVEUR CONVENT, DUNGARVAN, IRELAND.

piggeries, and back entrance. There is also an infirmary for sick cattle, which, with the piggeries, measures 150 ft. by 18 ft.

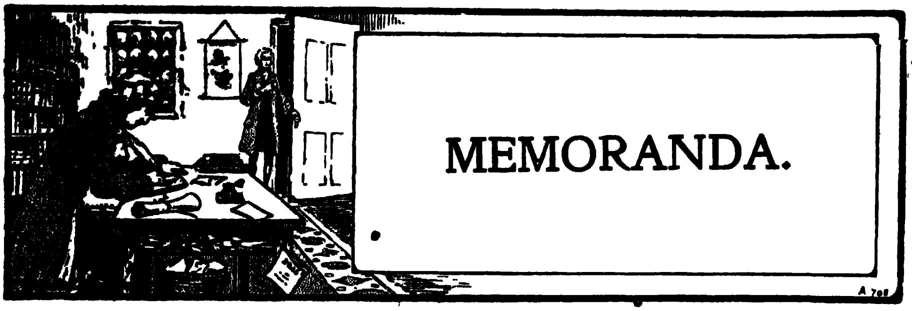
Fig. 2 shows the back of the main building.

The laundry to which reference has been made comprises, in addition to the laundry proper, a drying room, an ironing-room, and a mangling-room.

The illustration *Fig.* 3 shows the interior of the fold-yard, with the hay-sheds and lofts above same.

Special attention is called to the fact that most of the external walls of these buildings are built on the continuous cavity system, of which mention has been made earlier in the article. This system ensures a perfectly dry building, no matter what atmospheric conditions prevail, and further it is claimed that it is a most effective insulation against changes of temperature inside the building, inasmuch as it prevents condensation on the inside of the walls and an increase of temperature in hot weather or a lowering of the temperature in cold weather. These points may be considered of importance, and they apply equally to the cold, raw climates of the north and to the tropical countries.

The entire blocks and slabs were made on "Winget" machines, and the contractors were Messrs. John Hearne and Son, of Waterford.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.--ED.

The Society of Engineers (Incorporated).—At a meeting of the Society of Engineers (Incorporated) held on December 2nd, Mr. Percy J. Waldram, F.S.I., M.C.I., read a paper on "Test Deflections in Reinforced Concrete," a subject which, he stated, was one requiring the closer attention of engineers before a standard of deflection was fixed by the proposed L.C.C. regulations; a standard which might or might not be correct or even safe.

The stiffness of a beam was no criterion of its strength unless due regard were paid to the factors of depth and fibre stiffness. The small deflections of reinforced concrete beams were sometimes quoted as evidence of the strength of the material, but it was seldom noted that the deflections were small because the greatest loads placed on reinforced concrete were very much less than those commonly used upon wood or steel. Reinforced concrete was a much weaker material than steel or ordinary fir, for beams of equal size.

The draft regulations for reinforced concrete, compiled and approved by the London County Council, were submitted to the principal architectural and engineering institutions for criticism, and published in the Minutes of the Council. The author had been consulted in a case where the parties had agreed to work to the regulations as published, when the opportunity of applying them to the problem of a somewhat difficult design gave disquieting results. For instance, the clauses determining the strength of columns were quite unworkable, and those relating to deflection proved positively dangerous, as was shown by examples.

A standard of deflection suggested by the author was referred to, but he pointed out that the effect of end fixing was not yet fully determined, and that it was impossible to legislate on an uncertain basis. The minute range of the deflections made it all the more necessary to use the greatest care in fixing a standard.

Reference was then made to the calculations necessary to determine the strength of reinforced concrete beams, and a number of formulæ were given, with explanatory notes. The application of these to well-known tests was shown by a series of eight diagrams, and particular attention was directed to one in which the conditions were such as were generally supposed to make the calculations almost impossible, on account of their intricacy. The author, however, showed a method which he considered would very much facilitate the problem.

Reinforced Concrete for Hypochlorite Solution Tanks.—In a recent number of the *Concrete Age* a short article has appeared by Dr. Walter M. Cross, U.S.A., on the above subject. An experimental installation of the hypochlorite process for the approximate sterilization of the entire municipal water supply of Kansas City, Mo., proved so very successful in every way that the Fire and Water Board of Kansas decided to erect a permanent building and apparatus for the purification process of the water supply.

A separate building was constructed for storing, handling, and making the solution of hypochlorite for mixing with the sedimented water. The apparatus for the handling of the hypochlorite and the supports for it are of reinforced concrete. It was found that no other material was so well suited for the purpose.

The basement of the building is used for storage, the main floor houses the dilution

tanks and feeding devices, while the floor above is occupied mainly by the tank for the hypochlorite, in which it is reduced to a paste of creamy consistency before being delivered to the dilution tanks below. This concrete tank is 3 ft. in diameter and 4 ft. high, and is provided with a strong device carrying two heavy rollers placed horizontally at its lower end.

There are pipes leading from this tank to the dilution tanks below. These dilution tanks are hexagonal in form and are 9 ft. in maximum diameter and 7 ft. high. The dilution tanks rest on supports high enough to permit of the use of a gravity feed to the orifice box, which is on the floor of the room housing the big tanks. The writer concludes by saying that reinforced concrete is now everywhere employed in the United States in the construction of all permanent apparatus where hypochlorite is employed for mixing with the water to be purified.

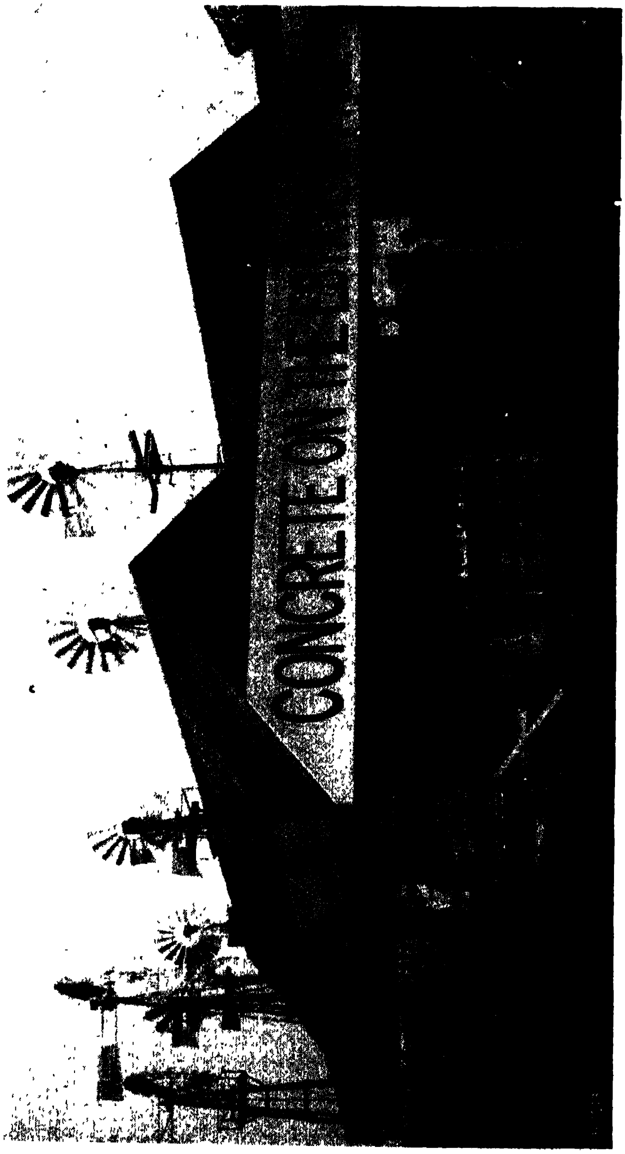
Concrete versus Wooden Poles.— According to the *Electrical World*, the Carnegie Steel Co. recently conducted tests on reinforced concrete poles at its South Sharon (Pa.) plant, for the purpose of determining the relative cost and strength of concrete as compared with wood. The poles tested were 32 ft. long, 10 in. square at the butt and 6 in. square at the top. The corners were bevelled and iron steps bent up ¾ in. were inserted in the forms before the concrete was poured. The mixture employed consisted of 1 part of cement, 2 parts of sand passing a ¼-in. screen, and 4 parts of crushed limestone passing a ¾-in. screen but retained on a ¼-in. screen. Each pole required about a barrel of cement, ¼ yard of sand, and ½ yard of stone. The reinforcement comprised four groups of twisted rods at the corners, placed not less than ¾ in. from the surface. Each group was made up of one ½-in. rod 32 ft. long, two ½-in. rods 24ft. long, and two ⅜-in. rods 16 ft. long. The reinforcement was thus proportioned to the decreasing stress toward the top of the pole. Sheet-steel separators held the reinforcement in place and were cut away to avoid breaking the continuity of the concrete above and below the separator. The forms used consisted of an upper and a lower section held together by bolts, the lower being a single piece, while the upper was made up of a series of units beneath which the concrete was forced. Each pole weighed about 2,500 lb., or approximately five times as much as a wooden pole of the same length. The tests were conducted with two concrete poles and a 32 ft. chestnut pole under the same conditions. It was found that the wooden pole showed practically the same deflection as the poles of concrete up to 2,000 lb., the load being applied at right angles to the pole and at the top. The deformation at 2,000 lb. amounted to 25⅝ in., this loading being far greater than could ever be experienced with the poles in actual use. For deflections of less than 15 in. the concrete pole showed no permanent set. A test to destruction was carried out on one of the poles, and failure resulted at the point where the 24 ft. reinforcement rods ended, the concrete being crushed for about 3 ft. above and below the break. The results obtained showed that the cost of manufacture of such poles should be from 30s. to £2, as against 16s. to £1, the price of a wooden pole. The cost of wooden poles is thus from one-half to two-thirds that of the concrete poles, and their life ranges from a minimum of ten years to a maximum of twenty years, whereas the life of a concrete pole is considered to be practically unlimited. Moreover, the concrete poles require no painting.

New Stores at The Camber.—Some new stores are to be erected for the Portsmouth Camber and Docks Committee, and the buildings are to be of reinforced concrete. The contract for the work was put out to tender, and the tender of Messrs. McLaughlin Co., which was the lowest, was accepted.

Portland Cement for Roofing.—A cheap and durable fire-resisting roofing is made in France with asbestos and Portland cement, in the proportion of one-fifth of asbestos fibre, one-fifth asbestos powder, and three-fifths Portland cement. The mortar, which must be carefully mixed, is pressed with the trowel into wooden moulds about 2 ft. square and one-fifth of an inch thick. These slabs, when perfectly set, are used in the same way as slates and nailed to the woodwork of the roof. This kind of roofing, which is very light and durable, is said to be very suitable for sheds and outer buildings.—*Sanitary Record.*

Reinforced Concrete Pillar Boxes.— It is reported that the cast-iron pillar-boxes in New Zealand are to be replaced by some made of reinforced concrete, as tests have shown that these boxes are stronger and lighter than the iron ones and cost considerably less.

How to Patch a Concrete Floor. — When a cement floor surface begins to wear, it is often desirable to patch it. Mr. Leonard C. Wason, president of the Aberthaw Construction Co., Boston, in a recent paper states the right way and the wrong way.

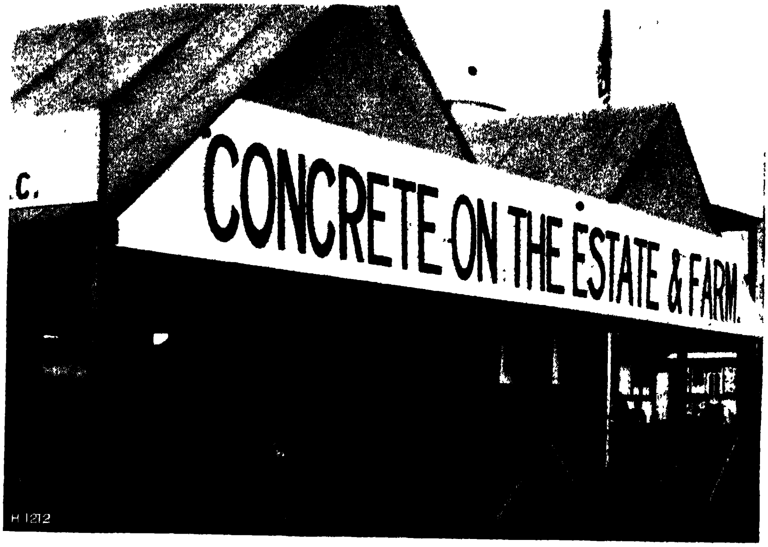


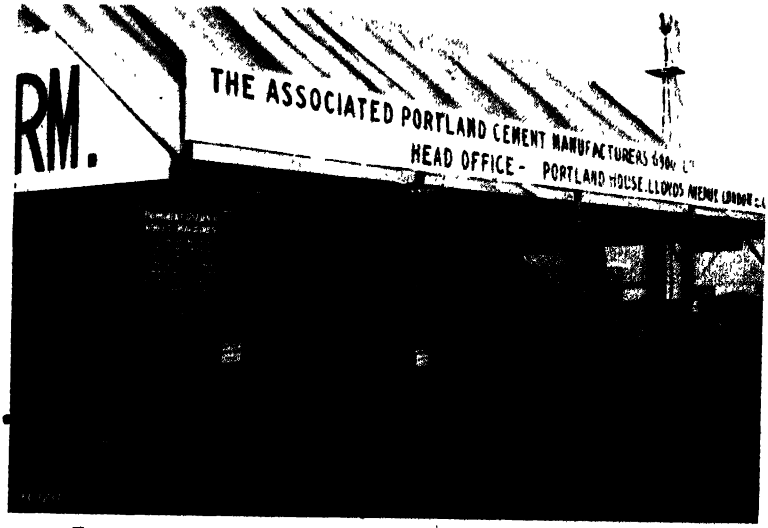
THE ASSOCIATED PORTLAND CEMENT MANUFACTURERS' STAND, AGRICULTURAL SOCIETY'S SHOW, DONCASTER.

The Wrong Way. — Commonly a sand and cement mortar is made, some cutting is done, and the mortar is put in and scrubbed with a steel trowel until smooth. It is then covered up for a while. If the concrete under the patch is left dry it soaks up the water of the mortar. As a result, the mortar does not set. If the room is dry or hot, the surface of the patch dries out for the same reason it does not set. If the concrete under the patch is dusty, the patch does not adhere to the concrete. If the materials in the mortar are not suitable, naturally the patch wears badly, particularly as it is obviously located at a point of severe wear.

The Right Way. — Cut down the worn place at least 1½ in. This cutting should be carried into the strong unbroken concrete and the edges should be cleanly undercut. The bottom of the cut should then be swept out, clean-blown out with compressed air or a pair of bellows, if available, then thoroughly wetted and scrubbed with a broom. In this way small loose particles of broken material which the chisel has driven into the surface are removed. A grout made of pure cement and water about the consistency of thin cream should be scrubbed into the pores with a broom or brush, both at the bottom and sides of the cut. Following this a stiffer grout, about the consistency of

soft putty, should be thoroughly compressed and worked into the surface which has already been spread with grout. Finally, before the grout is set a mortar made of one part cement to one part crushed stone or gravel, consisting of graded sizes from ½ in. down to the smallest, excluding dust, should be thoroughly mixed and put in place, then floated to a proper surface. Cover with wet bagging, wet sand, sawdust, or other





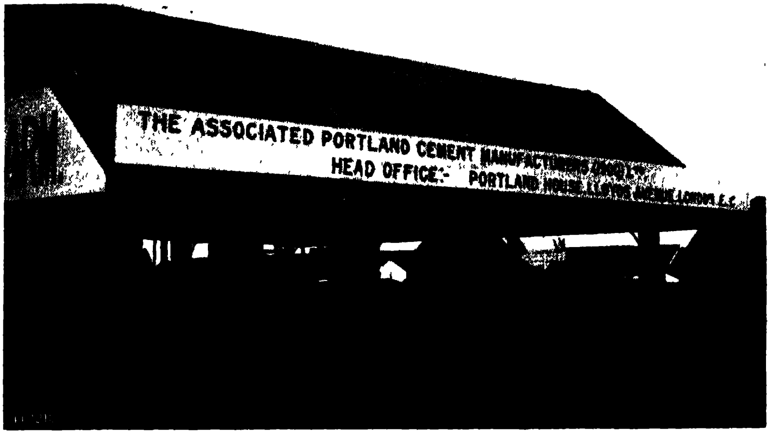
THE ASSOCIATED PORTLAND CEMENT MANUFACTURERS' STAND, AGRICULTURAL SOCIETY'S SHOW, DONCASTER.

available material. All trucking should be kept off and the surface kept thoroughly wet for at least one week or ten days.

If a particularly hard surface is required, a few nails are sometimes mixed with the mortar and other nails stuck into the surface when the patch is finished. This will produce a surface which is extremely hard and durable.

TRADE NOTICES.

Portland Cement at the Agricultural Society's Show, Doncaster.—Visitors to the Royal Agricultural Society's Show at Doncaster had the possibilities of the use of concrete on the estate and farm placed before them in a very striking manner at the stand of the Associated Portland Cement Manufacturers (1900), Ltd. Following out the educational policy which this company inaugurated at the previous year's Show at Norwich, they had a very large stand at which were displayed (for exhibition only and not for sale) all kinds of articles required for use on estates and farms. The rapid increase in the uses to which this material is being put was well illustrated by the fact that it was found necessary to have a stand exactly double the size of that at Norwich.



THE ASSOCIATED PORTLAND CEMENT MANUFACTURERS' STAND, AGRICULTURAL SOCIETY'S SHOW, DONCASTER.

There were displayed numerous reinforced concrete articles, such as rectangular and circular cattle troughs, hog troughs, chicken troughs, roofing tiles, flooring tiles, fence posts, and gate posts, and the moulds in which they were made. Many of these were of a similar character to those previously exhibited, except that parts were left unfinished so as to leave some of the ironwork exposed, thus showing the method of reinforcement and adding much to the interest of the exhibit.

The stand was surrounded on all four sides with various types of concrete fencing, and at the front of the stand, immediately behind a pair of field gates hung upon large concrete posts, was a large concrete facia, on one side of which was the company's name in raised letters, and on the other panels illustrating different types of surface finish. Looking at this, one could quite realise that concrete name plates and street signs might be used to great advantage, as they are practically indestructible and, above all, cost nothing for maintenance.

There were panels of "scrubbed concrete" on the other sides of the stand. The method for obtaining these results is very simple. As soon as the concrete is set (usually after about twenty-four hours) the side of the form is removed, exposing the surface of the concrete, which is then scrubbed with an ordinary scrubbing-brush to take off the film of cement and expose the aggregate. The use of various kinds of aggregate renders it possible to obtain a large variety of pleasing finishes in this way.

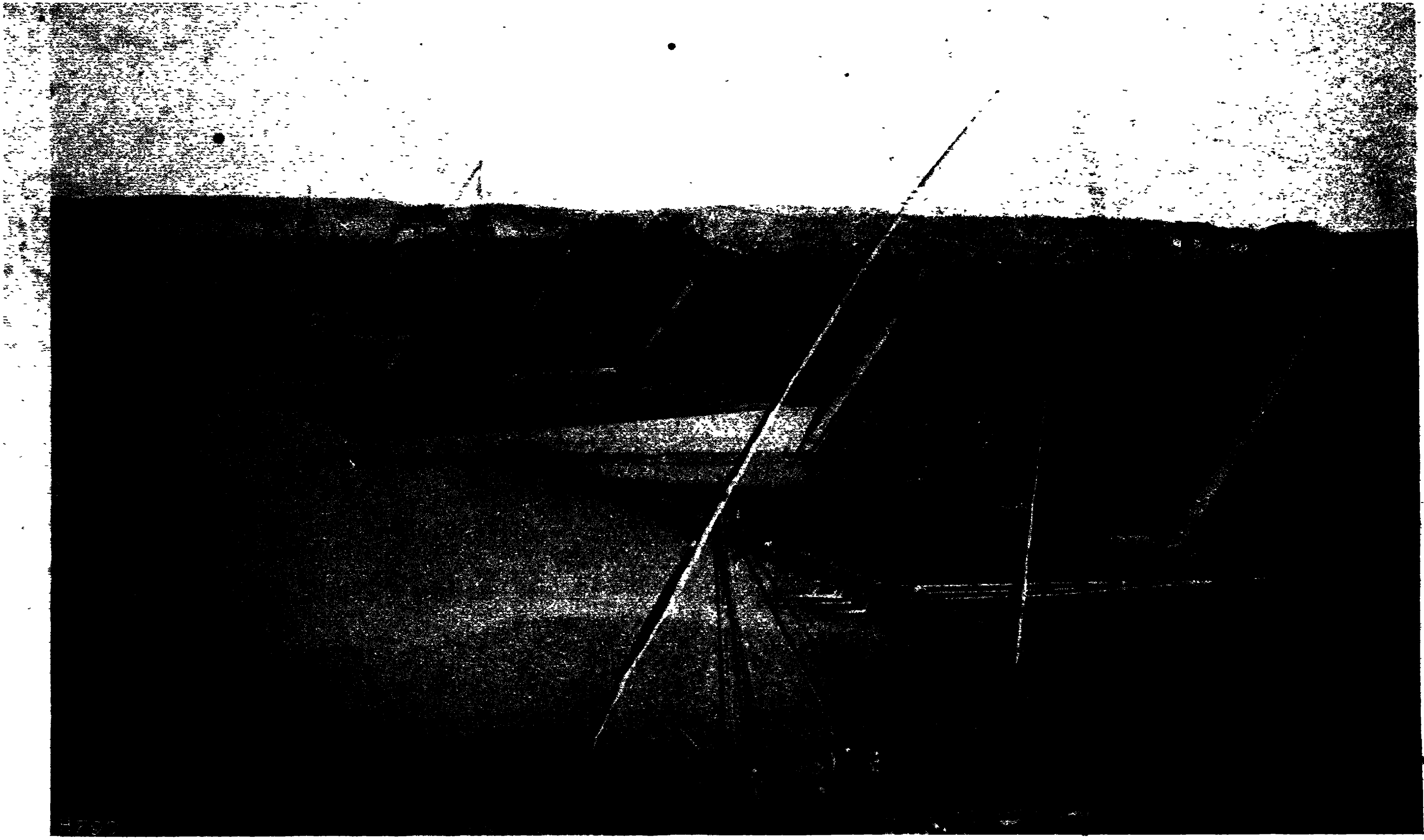
A section of a concrete cow stall was shown which created considerable interest, and no one concerned with the welfare of cattle could fail to be struck by the admirable hygienic and sanitary properties of such construction.

A lean-to roof partly covered with the concrete and asbestos "Poilite" tiles manufactured by Messrs. Bells Asbestos Co. and partly with ordinary slates indicated a saving of nearly 75 per cent. of weight by using "Poilite" roofing; the weights given being "Poilite" 21 lb., and Welsh slates 80 lb. per yard super.

The Associated Portland Cement Company distributed at the stand a considerably enlarged and improved edition of their valuable pamphlet, entitled "Concrete on the Estate and Farm," copies of which, we understand, they will be pleased to send to anyone interested upon receipt of request addressed to Portland House, Lloyds Avenue, E.C.

New Reinforced Concrete Loading Pier at Southend-on-Sea.—Construction work has commenced for the new loading pier which the Corporation of Southend-on-Sea has decided to erect under the superintendence of Mr. Ernest J. Elford, M.I.C.E., the Borough Engineer. The total length of the pier will be 600 ft., and it has been designed for a working load of 5 cwt. per sq. ft. The whole of the work will be executed on the "Piketty" system of reinforced concrete. Mr. T. W. Pedrette, Enfield, N., is the contractor. The contract is for £11,000. The Borough Engineer selected and recommended the adoption of the "Piketty" system after receiving designs in open competition from other firms of reinforced concrete specialists.

The Armoured Tubular Flooring Co., Ltd.—H.M. Office of Works have recently entrusted to the Armoured Tubular Flooring Co. certain works in connection with Hertford House, Manchester Square, where the valuable Wallace Collection is housed. The work, which has been carried out to make the building more fire-resisting, includes the reconstruction of the upper portion of the right wing. The old roof has been removed and the existing wooden floors have been taken out by the contractors, Messrs. Dove Bros., and a new fire-resisting floor has been installed on the armoured tubular system, also some flat roofs adjoining. The whole of the work has been carried out without any centering whatever. We hope in a subsequent issue to deal with this work more fully.



The Assouan Dam.
General View of the Dam.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Vol. VIII. No. 2.
February. 1913.

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume VIII. No. 2. LONDON, FEBRUARY, 1913.

EDITORIAL NOTES.

THE ASSOUAN DAM.

THE completion of the Assouan Dam—one of those great achievements of British thought and work which will materially benefit many thousands of human beings, and stand for many centuries as a landmark of British enterprise—was accorded somewhat less space in the public Press of this country than is given to a fashionable fancy dress ball, and certainly much less than to some notorious law case. Another feature regarding the reports of the completion of this work was that they seemed studiously to avoid giving the slightest tribute or praise to that splendid band of technical workers, both skilled engineers and foremen, who, by forethought, energy and diligence, not only played an all-important part in the carrying out of this great scheme, but to whom must be attributed the highest praise for precision combined with smartness, under circumstances that were frequently exceedingly trying.

We have dealt with the Assouan Dam at considerable length in our issue of April, 1911, which was illustrated with the most perfect photographs available, and we do not hesitate to reprint our frontispiece of that issue, as a reminder of the extent and grandeur of this work. It is, therefore, unnecessary to recapitulate the numerous figures presented with our article as to the size and effective value of the undertaking.

Only in one direction do we again wish to emphasise some views expressed by us on the occasion of that article—viz., in respect of the submersion of the Temple of Philae. We would repeat that this temple is one of many ruins situated between Cairo and Wadihalfa, and although ancient temples as a whole are of the greatest possible interest, the single specimen is a mere entity. Whether one or a dozen of the ruins disappear to-day is merely a matter of sentimental regret. We have all the historical records we require, and the practical loss would be *nil,* for there is no utility in the ruins, except, perhaps, as some slight attraction to tourist money to Upper Egypt.

It is well indeed that this temple has not been allowed to stand in the way of the development of Egypt; to have permitted it to act as a deterrent would have been as unreasonable as it would have been inhuman. Humanity requires that our knowledge, skill and means be applied to the improvement of mankind. The lot of the Egyptian is vastly improved by the Assouan Dam. With the increased prosperity of Egypt, funds become available for the better hygiene and sanitation of that country, for the reduction of eye-diseases, for elementary education, and for general civilisation, and it is absurd to expect that such benefits should be prevented or retarded by egoistic art-lovers, who, for the most part, know little and care less for Egypt.

The great Assouan Dam is therefore not only an immense work realised, but a distinct victory over morbid sentimentalism in the matter of second-rate ruins, and shows that common-sense is wanted where hysterical hypocrisy so frequently and unfortunately gains its way.

One last word. We see that the primary worker in respect of the successful completion of the Assouan Dam—Mr. Murdoch Macdonald, C.M.G.—has now been appointed to the highest office available in the Egyptian Ministry of Public Works. We congratulate him upon this well-earned compliment; we also congratulate Lord Kitchener upon putting the right man in the right place. When some day the true history of the Assouan Dam comes to be written, it will easily be seen that the influence of this worker on the spot has been of even greater importance to the undertaking than that of others who have perhaps figured more conspicuously in the public Press, and it is to be regretted that some of our greatest works and workers are almost invariably not accorded that credit which is due to them in great engineering enterprises.

AN ACTIVE CONCRETE INSTITUTE.

WE have received particulars of the impending annual meeting of the German Beton-Verein which is to be held at Berlin on February 13th and 14th, and we are struck by the excellence of their programme.

Apart from the usual annual report, there will be a special report on the Testing Commission of this body, which has done such valuable research work in the past. There will be a report on the co-operation of the Society in the Building Exhibition to be held at Leipzig next summer, and a similar report on the question of Arbitration as applicable to the concrete and reinforced concrete industry. Two of the leading authorities on research work in Germany are presenting lectures—viz., Professor Rudeloff on "Tests with Columns," and Professor Gary as to the "Rusting of Metal and Brickwork." Dr. Trauer is presenting a paper on a gigantic auditorium of reinforced concrete construction which is at present being erected at Breslau. Mr. Christiani reports on "Reinforced Concrete Quays," whilst four other members are presenting papers on notable buildings carried out during the past year. Besides this, three précis will be presented, one on "Failures in Building Construction," a second on the "Effect of Earthquakes on Concrete and Reinforced Work," and a third on the "Effect of Explosions on Concrete."

Surely this is a remarkable and eminently interesting programme of work, which is of the greatest possible credit to the Society in question, and a programme of this description is not only highly instructive and beneficial to the members of this Institute, but raises its work to a position where it cannot fail to be appreciated by all concerned, and the public authorities in particular.

Our own Concrete Institute would do well to take a leaf out of the book of their allied Institute's Berlin programme.

REINFORCED CONCRETE FAILURES.

WHEN the Concrete Institute had been fairly started, some four or five years back, one of the first pieces of work suggested as a safeguard to the professions and industries alike—suggested by their first chairman—was the careful investigation of the reinforced concrete failures, as affording some of the best practical lessons as to precautions to be observed and errors to be avoided.

But there has always appeared to be some diffidence as to getting to work really seriously on this all-important subject, this being mainly due to that extraordinary fear of responsibility which prevails among professional men who cannot realise that a statement of fact in the public interest, properly and conscientiously put, can never be a libel, and partly owing to a certain fear among those of the members of the Institute who are concerned with the specialist firms, that some failures of theirs might come under view to the detriment of their standing. Recently, however, a small sub-committee has been formed to go into the matter, but certainly up to the present we have heard of no case of systematic investigation, nor have we seen any programme of how the inquiries are to be conducted.

England has fortunately been fairly free from serious accidents in reinforced concrete work, although there have been several notable ones which do little credit to those primarily concerned. Fortunately, however, we have not come across any accidents of this kind which can be attributed directly to anything that might be detrimental to the interest of reinforced concrete as a whole, inasmuch as none of these accidents have so far shown that reinforced concrete, if properly designed and properly executed by competent and responsible people, is in any way more dangerous than any other form of building construction properly designed and properly executed. The failures have been largely due to negligence, stupidity, or sheer scamping.

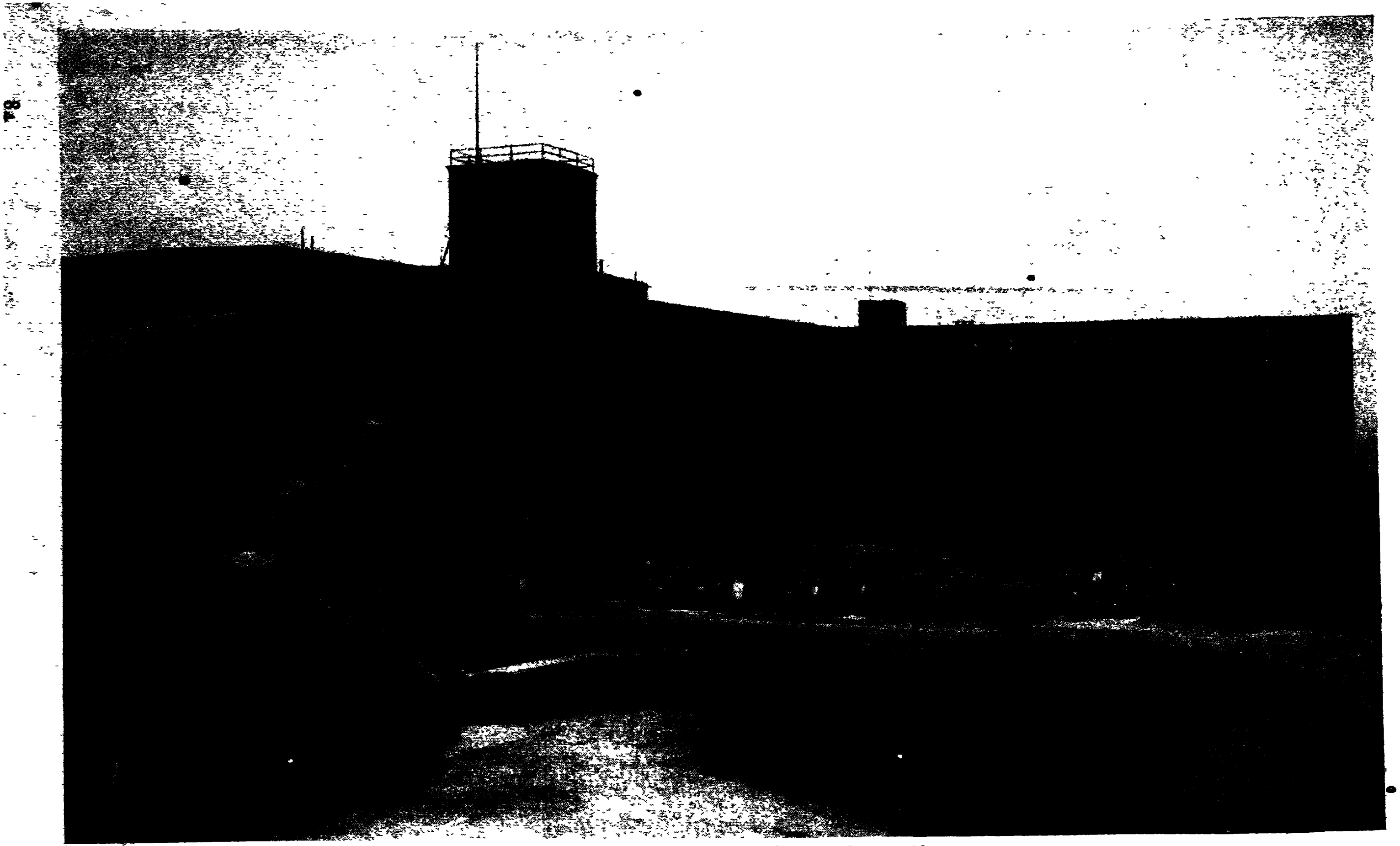
There are two words of warning on the matter of failures which we would like to give.

The first is to the builder or contractor. It is to the effect that it is unwise to handle reinforced concrete in any form, unless to the design and specifications of experienced men, and unless carried out honestly by experienced artisans. There is no form of building construction that is more dangerous when subjected to false economy or dishonesty than reinforced concrete construction.

The second is addressed to the reinforced concrete specialist who combines designing with contracting, and that is, that the present competition to obtain work at entirely unsuitable prices must be disastrous to the development of the work they have in hand, and if they do not have immediate disasters actually during the course of construction, the manner in which they are often "cutting things fine" in design and quality of materials must obviously result in prospective failures when the effect of their scamping becomes apparent upon the structures they have put up when subjected to the strain of actual usage.

It is to the interest of all those industrially concerned to stop this scamping in design and poor workmanship promptly, even if they have to be satisfied with a lesser return for their work, for if failures through bad design or scamping increase, reinforced concrete—which has been adopted with reluctance in this country—will suddenly become as unpopular as certain other forms of buildings have become, and those who wish to earn their living thereby will have to find fresh fields, instead of sensibly developing their present one.

The professions and industries concerned must further plainly face the actuality of failures, investigate the causes thereof, and publicly censure those who are responsible for them, if they wish the reinforced concrete industry to flourish.



New Rubber Workshop, Elevation from North-East Side.

Extension of Messrs. Siemens Bros.' Works, Woolwich.

EXTENSION OF WORKS —SIEMENS BROS. & CO., WOOLWICH.

By F. SOUTHEY, A.M.Inst.C.E.

The following particulars of the extension of Messrs. Siemens's works may not be without interest to those contemplating additions or alterations to similar buildings.—ED.

IN the new buildings recently erected for Messrs. Siemens Bros. & Co., at Woolwich, concrete and reinforced concrete have been used on a large scale. Concrete has been used exclusively in the foundations and reinforced concrete in the floors, roofs, columns, staircases, and lintels in the superstructure. The walls are in brickwork, with piers to take the load on the floors and brick panelling and window openings between. This method of construction was adopted in the case of two large and one smaller building, and a short description of each, with special reference to the concrete work, may not be without interest.

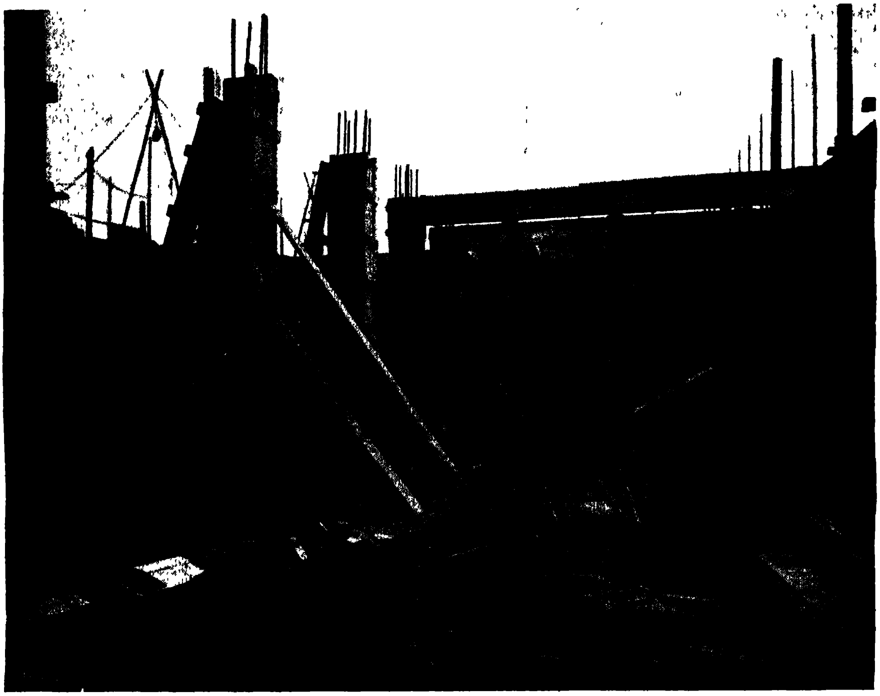
NEW RUBBER WORKSHOP.

This building, containing a capacity of nearly two million cubic feet, is in plan composed of two wings or blocks, forming at their junction an angle of 94½ degrees. The south block is 320 ft. in length and the west block 202 ft. in length, measured from the external point of intersection of outer walls. The uniform width between external faces of piers is 50 ft. 9 in. There are six floors, including the basement, giving a total floor area of just over three acres. The height from basement floor to mean roof level is 79 ft.

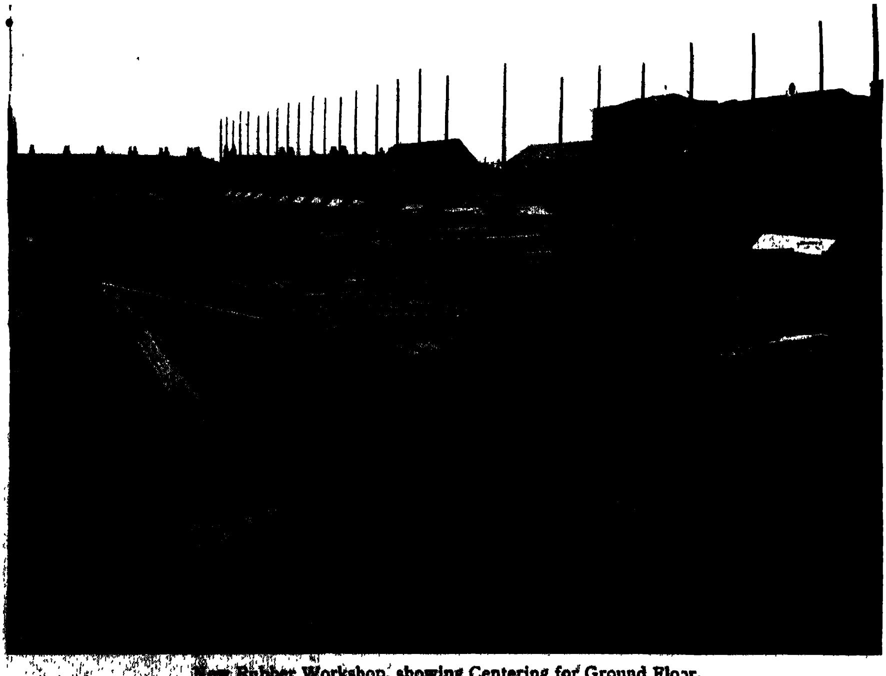
The building is supported on 153 concrete piers founded on sand. The piers are 5 ft. by 3 ft. 6 in. under walls, 5 ft. by 4 ft. under columns, and 5 ft. by 5 ft. at corners. They varied in depth from 7 ft. to 14 ft. 9 in. below basement floor level, which is itself 7 ft. 6 in. below general ground level. The base of each pier was extended on all sides by undercutting in order that the distributed load on the sand should not exceed three tons per square foot. 3,000 cub. yds. of concrete were placed in piers and trenches, the concrete (as is the case with the other buildings) being composed of 1 part of Portland cement to 6 parts of Thames ballast with a suitable proportion of "plums." Gravity concrete mixers were used for the bulk of the foundation work.

A single row of 28 columns along the major axis of the south block and 12 in the west block divides the width into two equal spans of 22 ft. 9 in. These columns carry transverse beams, there being no secondary beams excepting in one end bay of longer span.

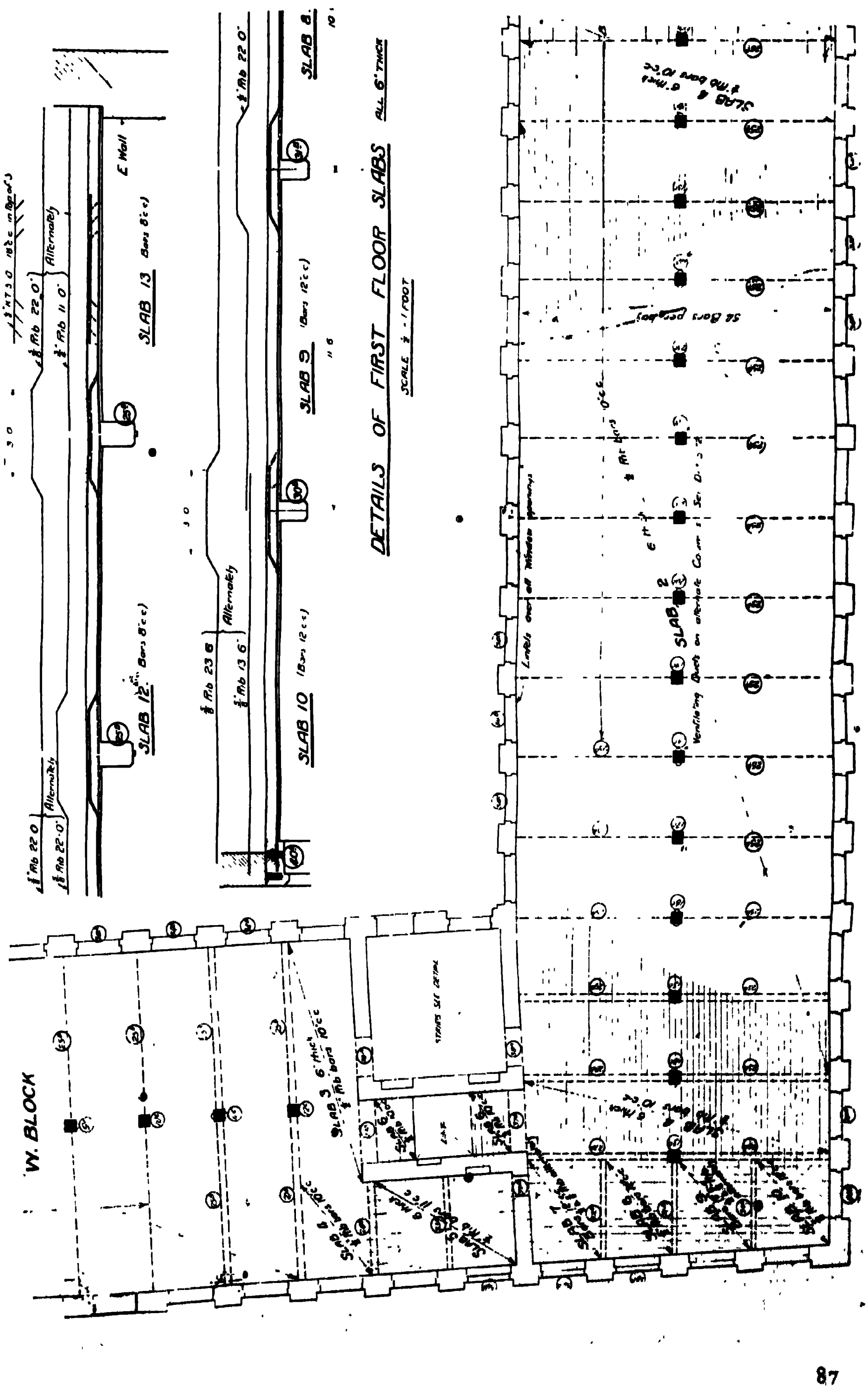
The columns on each floor are uniform in size; they are 21 in. by 21 in.



New Rubber Workshop, Shuttering for Beams and Columns
EXTENSION OF MESSRS. SIEMENS BROS.' WORKS, WOOLWICH.



New Rubber Workshop, showing Centering for Ground Floor.
EXTENSION OF MESSRS. SIEMENS BROS.' WORKS, WOOLWICH.



Ground Floor Plan Rubber Workshop, showing First Floor Construction.
EXTENSION OF MESSRS. SIEMENS BROS.' WORKS, WOOLWICH.

under ground floor, 18 in. by 18 in. under first floor, and 16 in., 15 in., 12 in. and 10 in. square under second, third, fourth, and roof respectively. They are chamfered at the corners.

The south block columns carrying the ground floor are reinforced with eight rib bars, four $\frac{7}{8}$-in. set at each angle, and four intermediate of $\frac{3}{4}$-in. section, while those in the west block are equal in number but of larger sectional area, being respectively four 1-in. and four $\frac{7}{8}$-in., the heavier bars being placed at the corners in every case. This increase in the case of the west block as compared with the south on account of the extra load carried continues upwards. Columns under first and second floors have also eight vertical rib bars, but those under third, fourth

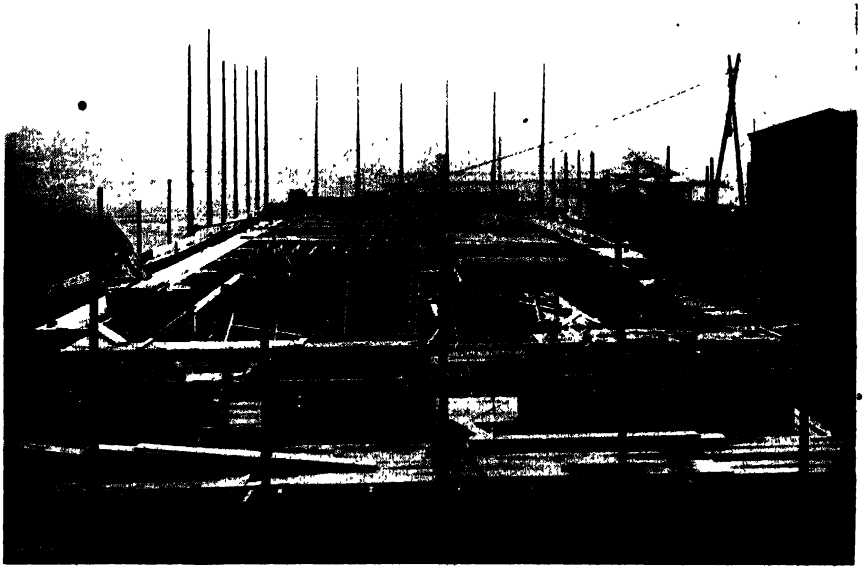
New Rubber Workshop, Third Floor.
EXTENSION OF MESSRS. SIEMENS BROS.' WORKS, WOOLWICH.

and roof have only four. The sectional area of steel, as well as the size of column, diminishes as the point loads decrease, and the columns under roof contain four $\frac{1}{2}$-in. rib bars only. All columns are bound with $\frac{3}{16}$-in. mild steel wire ties up to third floor level at 12-in. centres, under fourth floor at 10-in. centres, and the roof columns at 9-in. centres. These binders are threefold, square over all, and bracing opposite intermediate verticals. The beams are generally 20 in. by 10 in., measuring 14 in. by 10 in. below the 6-in. slab. They are reinforced with $1\frac{3}{4}$-in. trussed and rib bars of varying size to complete the required sectional area, which are cranked up for shear and carried over columns for continuity. On all the floors and roof $4\frac{3}{4}$-in. by $1\frac{3}{4}$-in. R.S.Js. are cast in the

beams, the bottom flange projecting 1 in. below the soffit for shaft and machinery fixing; these are tied in by means of hairpin stirrups passed through holes in the upper part of the web.

The slabs are uniformly 6 in. thick and reinforced with rib bars of varying size, spaced from 8 in. to 12 in. between centres, the bars of each slab being cranked up over the beams for shear and continuity, while end slabs have inverted trussed bars placed on 18-in. centres in the top to assist compression. The roof slab has an over-sail forming a cornice reinforced with $\frac{3}{8}$-in. rib bars, spaced 2 ft. apart, and the whole surface is covered with ruberoid.

The following gives the calculated superloads on the respective floors in the west block, where the maximum loading occurs :-- Ground and second floors,



New Offices and Store, showing Floor in Course of Construction.
EXTENSION OF MESSRS. SIEMENS BROS.' WORKS, WOOLWICH.

3 cwt. per sq. ft.; first floor, $1\frac{1}{2}$ cwt.; third floor 2 cwt.; and fourth floor 1 cwt. per sq. ft.

The two internal staircases are in reinforced concrete with landings and risers carried on main and stringer beams reinforced with trussed bars.

The concrete in the reinforced work was gauged 1 part of Portland cement, 2 parts of clean sand, and 4 parts of Thames ballast crushed to pass a $\frac{3}{4}$-in. mesh. For the mixing of this two concrete mixers of the Swiss type were used. About 3,500 cub. yds. of concrete and 230 tons of steel reinforcement were used in the superstructure.

On the roof are placed two gearhouses in connection with the working of the lifts. In each block an external iron staircase is provided for exit in cases of emergency.

NEW OFFICES AND STORE.

This is a building of five storeys, 90 ft. in length by 40 ft. in width, with an annexe and lean-to roof 25 ft. wide running the whole length of the west side.

The main building is supported on 18 concrete piers founded on sand. These piers varied in depth from 22 ft. 6 in. to 28 ft. below ground level. The central row of six piers (each 5 ft. by 3 ft.) supports columns that divide the internal width of 36 ft. 6 in. into two unequal bays of 22 ft. and 14 ft. 6 in. respectively. The piers under the east wall (on which side is the longer span) are 5 ft. 3 in. by 3 ft. 6 in., and those under the west wall 4 ft. 6 in. by 3 ft. The corner piers were made square to the larger dimension in all cases. The trench concrete is reinforced with steel girders, and these act as beams for supporting the walls.

The reinforced concrete columns are square, with chamfered angles, measuring 16 in. by 16 in. on ground floor and 14 in., 12 in., 10 in. and 9 in. respectively on first, second, third, and fourth floor. They are reinforced with rib bars, there being eight $\frac{7}{8}$-in. rib bars in the ground and first floor columns, four 1-in. rib bars in those on second floor, four $\frac{7}{8}$-in. at third floor level, and four $\frac{1}{2}$-in. supporting roof. All are bound with $\frac{3}{16}$-in. wire at 12-in. centres, and in the case of those at ground and first floor levels are cross bound in addition. Spanning these columns a continuous beam reinforced with Kahn and rib bars (the latter bent over supports for continuity) and 24 in. deep by 9 in. wide runs the full length of the building, and this, apart from the staircase and lintels, is the only beam on each floor, the span to walls on either side being flat on soffit, constructed in the Kahn tile system. These hollow tiles are uniformly 12 in. by 12 in. on plan, and vary in height according to the depth of floor as called for by the requirements of load and span. They are placed in rows across the span, a 4-in. interval separating each row, the tiles being stopped some distance from the beam, so that the table of the beam may be formed in solid concrete for T action. The concrete is then cast in the troughs between the rows of tiles (embedding the reinforcement) and is floated over the tiles to the required depth, thus constituting a monolithic series of small continuous T beams. The tiles in this system are not called on to do work, but merely to occupy space and give a flat soffit. These spans are, as mentioned above, 14 ft. 6 in. and 22 ft., but it is interesting to know that spans of 30 ft. to 40 ft. are possible in this method. In the case of the 22-ft. span, the 12 in. depth of floor is made up with 10 in. tiling and 2 in. of concrete, while for the roof 8 in. depth of tiling with 1 in. concrete float sufficed, the reinforcement consisting of $\frac{3}{4}$-in. bars on 16-in. centres, thus giving the concrete joist between tiles a width of 4 in.

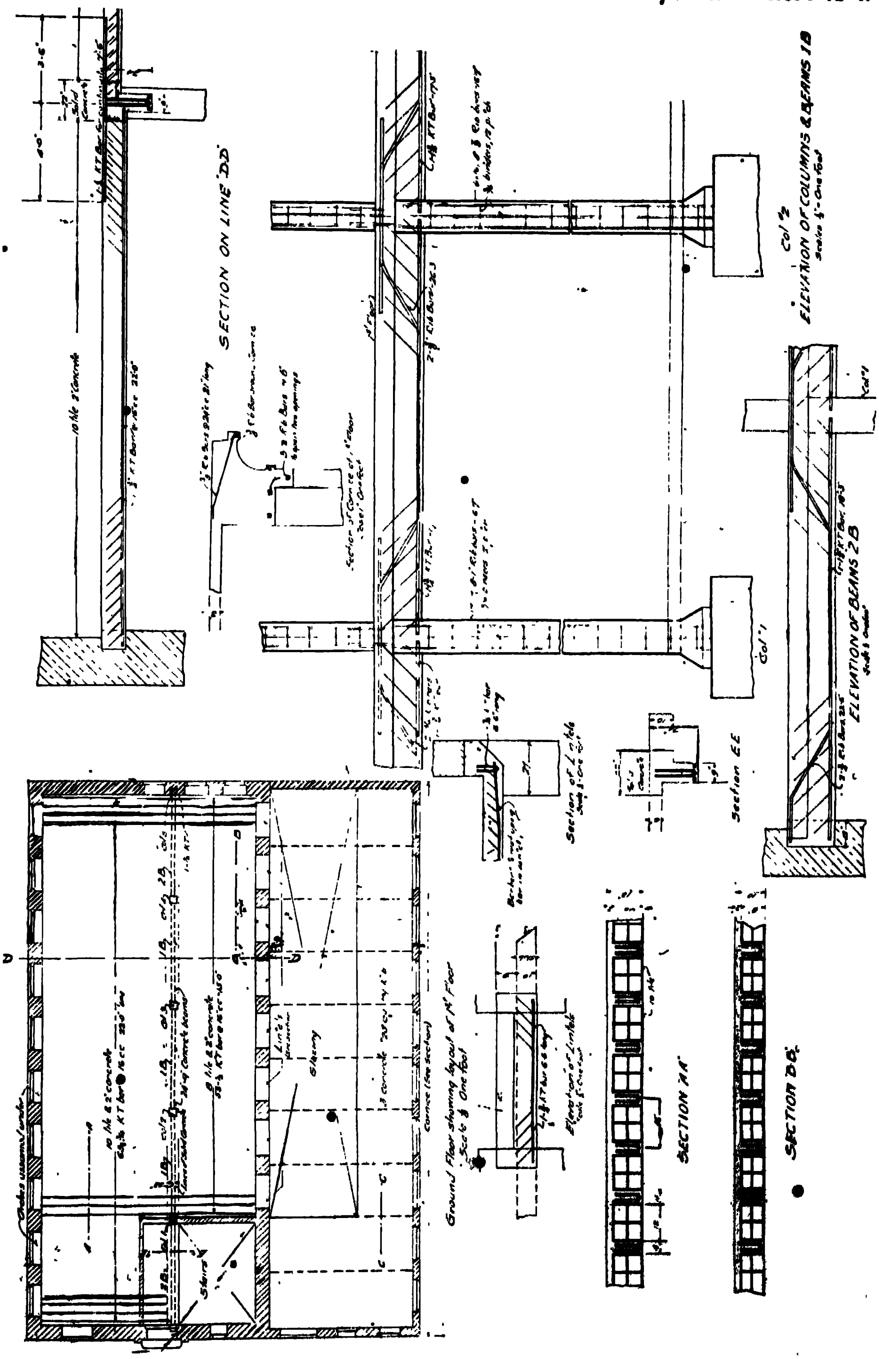
The staircase is carried by 14-in. cranked stringer beams 6 in. wide, reinforced with rib bars in the bottom.

All the walls, columns and ceilings in the main building are plastered with Sirapite.

The concrete was composed of 1 part by volume of Portland cement, 4 parts of washed river ballast crushed to pass a $\frac{3}{4}$-in. mesh, and 2 parts of sand.

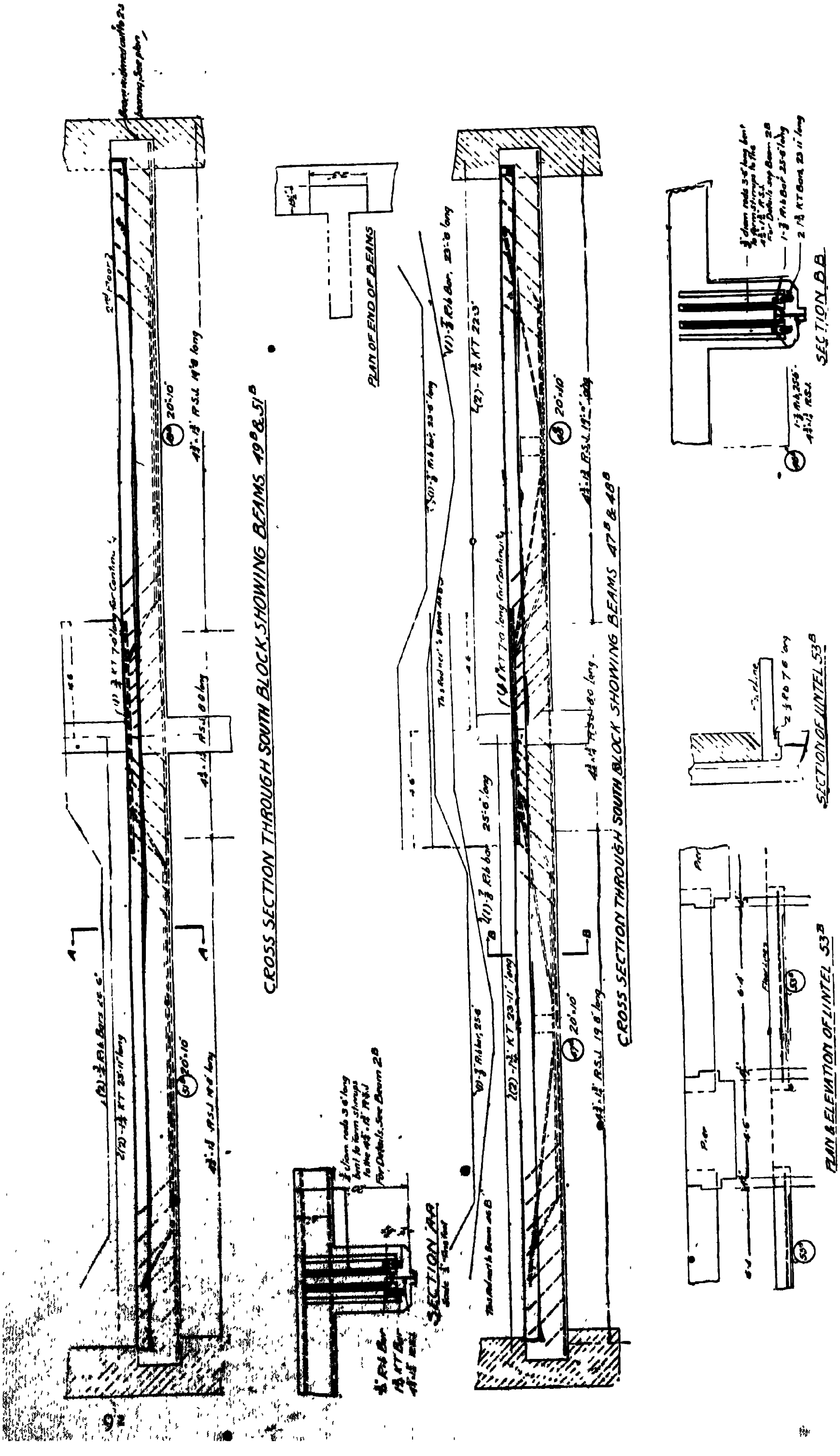
NEW TELEPHONE WORKSHOP.

This is a building of six floors with a mean length of 325 ft., width of 45 ft., and height from basement floor to underside of roof 78 ft. There is a large

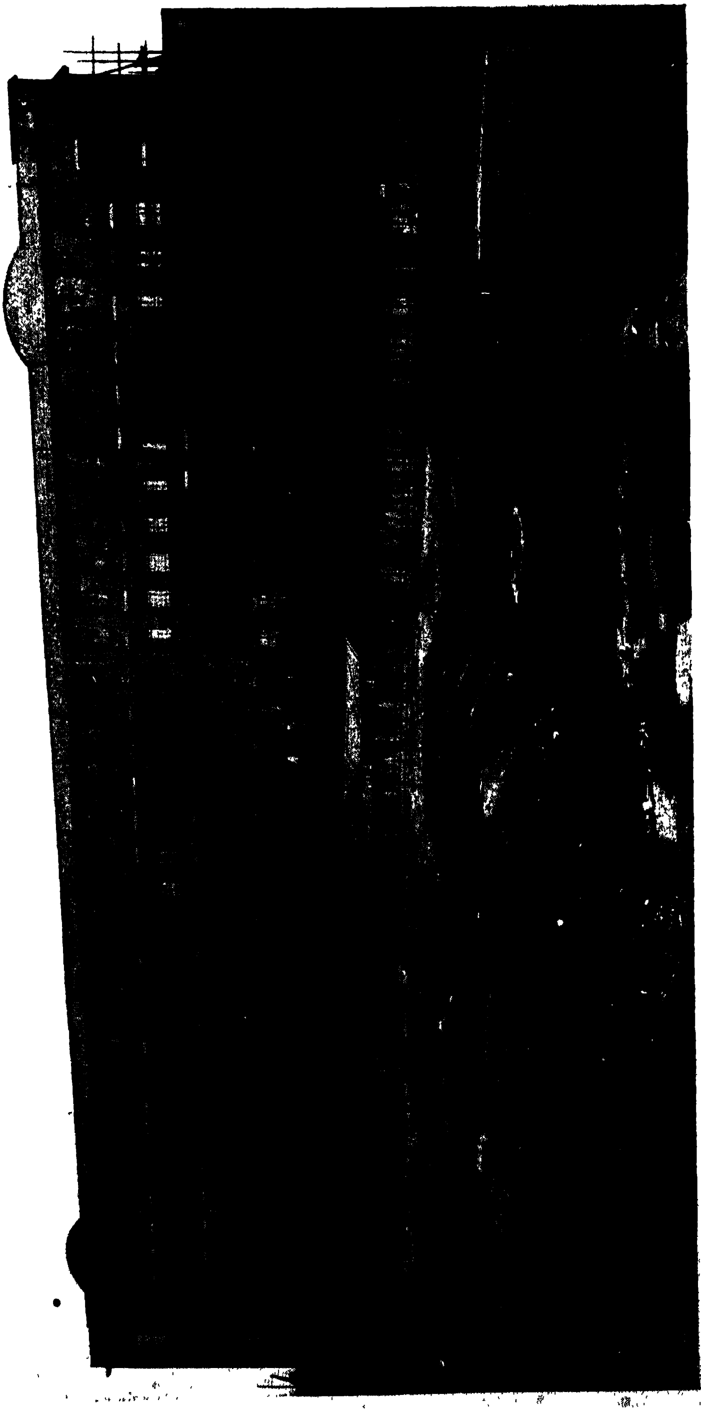


New Offices and Store.

EXTENSION OF MESSRS. SIEMENS BROS.' WORKS. WOOLWICH.

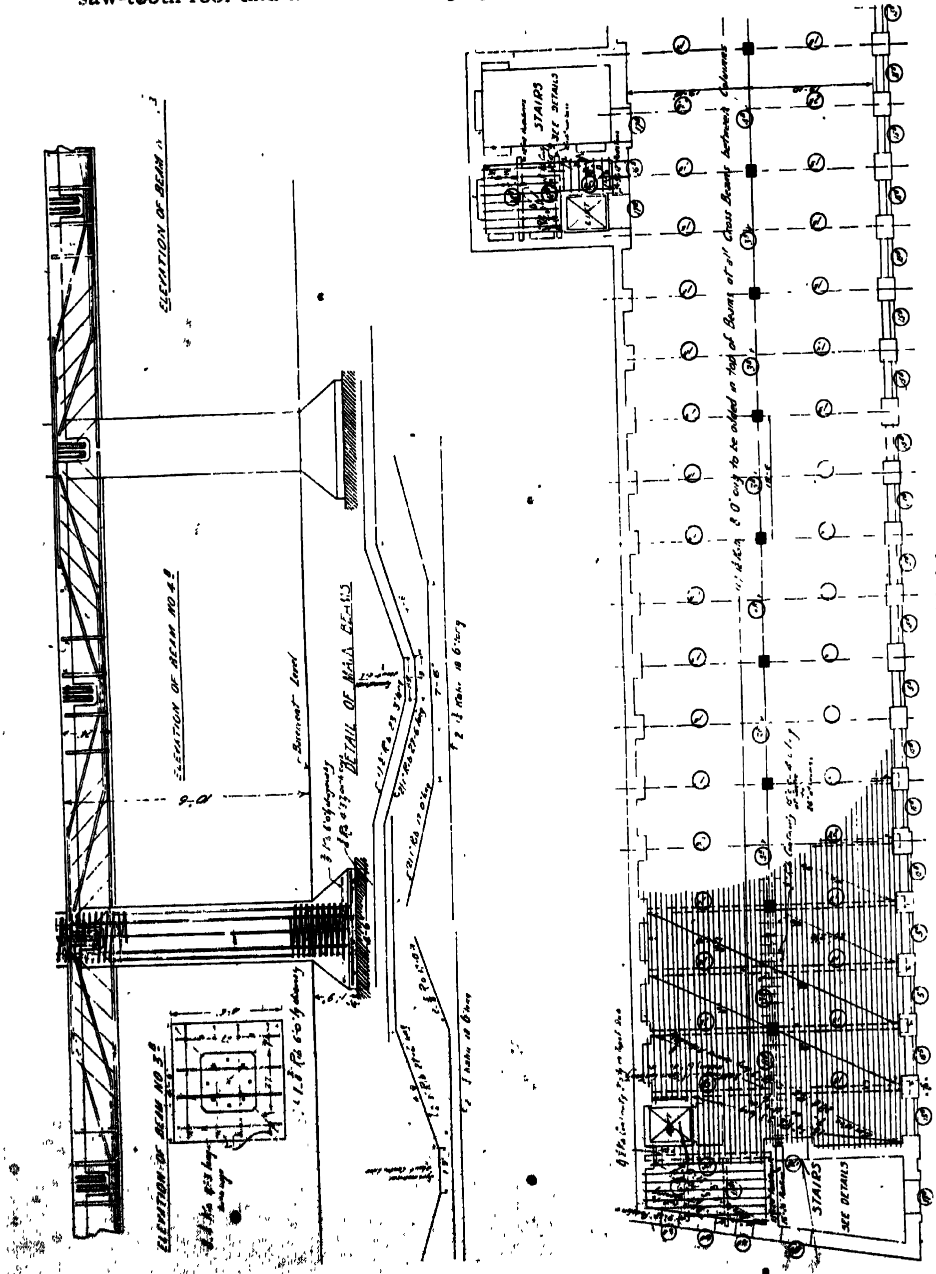


Section showing Beams for Roof.
EXTENSION OF MESSRS. SIEMENS BROS.' WORKS, WOOLWICH



New Telephone Workshop.
EXTENSION OF MESSRS. SIEMENS BROS.' WORKS, WOOLWICH.

machine shop of one storey adjoining this building on the north side with a saw-tooth roof and a floor area of 38,300 sq. ft.



New Telephone Workshop
Extension of Messrs. Siemens Bros.' Works. Woolwich.

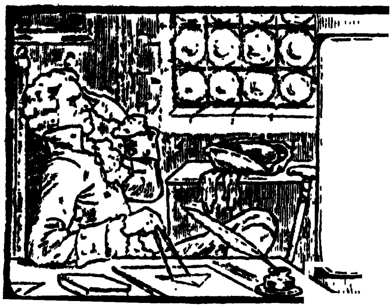
This building presents many constructional features similar to that of the new rubber workshop, so that a brief reference to the leading points of difference would suffice.

The foundation piers are placed at 18-ft. 6-in. centres, and a series of continuous reinforced concrete foundation beams afford direct support to the brick wall piers, which are spaced 9 ft. 3 in. between centres. The columns under ground, first and second floors are all wound with helicoidal reinforcement. This was supplied to required diameter ready coiled, and was fixed and wired in place according to pitch.

A single continuous longitudinal beam on every floor and roof extends the whole length from column to column, intersected by secondary transverse beams, each of which has a bearing at one end on the wall pier.

A parapet wall with a concrete coping serves both as a suitable finish to the south side fronting the street and a means of affixing the title of the firm in skeleton letters.

It may here be stated, in conclusion, that Mr. W. Dieselhorst, the works general manager of Messrs. Siemens Bros. & Co., was responsible for the general design of the whole scheme, the architects being Messrs. Herbert and Helland, on the staff of the same firm. Messrs. Holland & Hannen were contractors for the two large builings, and Messrs. Mowlem & Co. the contractors for the smaller building—viz., the new offices and store. The Trussed Concrete Steel Co. were the specialists for the reinforced concrete work, and supplied all the steel reinforcement.



STOPPING PLANES IN REINFORCED CONCRETE.

By EDWARD J. STEAD, Assoc.M.Inst.C.E.

The question of Stopping Planes in reinforced concrete is one that still calls for much attention and study, and the following article on the subject may therefore prove of interest to our readers. - *ED.*

It appears to the writer from considerable experience of reinforced concrete construction that insufficient consideration is as a rule given to the determination of positions of stopping planes in this class of work.

Beams and Slabs.—In concreting beam and slab works it is a common practice to fill up the beam forms to the level of the underside of the slab, then at a later stage of the work to follow over with the slab concreting separately. During the interval the surface of exposed concrete receives more or less injury from dirt, etc., and it has frequently been noticed that the shear reinforcement gets flattened down and knocked out of shape. These circumstances result in a plane of weakness as regards horizontal shearing on the line *a*—*b* in *Fig.* 1. It has further been observed that the stopping planes in the slab concreting are often made vertically over the longitudinal centre lines of beams, as at *c*—*d* in *Fig.* 1.

In this type of design the beams are in general calculated as T-beams, and, notwithstanding the fact that many successful constructions have been carried out in the method indicated, it is submitted that it is undesirable to make temporary joints in the positions shown. No matter how carefully the surfaces are cleaned and roughened the homogeneity so greatly desired cannot be secured.

To obtain the full value of the area of concrete in compression—*i.e.,* that portion of the beam proper which lies above the neutral axis, together with the width of the slab acting with it—stopping planes should be excluded so far as practicable from that area. Unless the vertical reinforcements in the beams maintain their intended shapes and positions, are rigidly attached to the tensile reinforcement, and well concreted into the compression area, the resulting construction approaches that of a rectangular beam of depth *a*—*e* with the slab resting upon it, and the strength will be considerably less than the designer intended.

As a matter of practical construction, stopping planes must occur somewhere in the concrete, and it is suggested that in the case of beams in one direction only—*i.e.,* no secondary beams—the better practice is to cast the beam and slab in one operation, as shown in *Fig.* 2, in which the dotted lines *f*—*g* and *h*—*j* represent joint lines parallel with the beams and at the centres of the slabs between them. There can be no serious objection to the joint through

the slab, as it is at right angles to the direction of the main reinforcement, the bars of which being continuous over two or more beams ensure full tensile

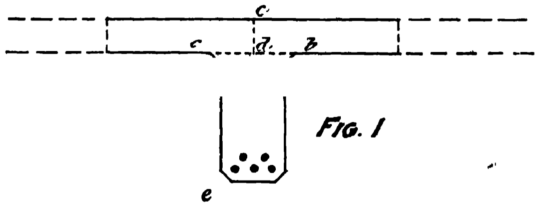


FIG. 1

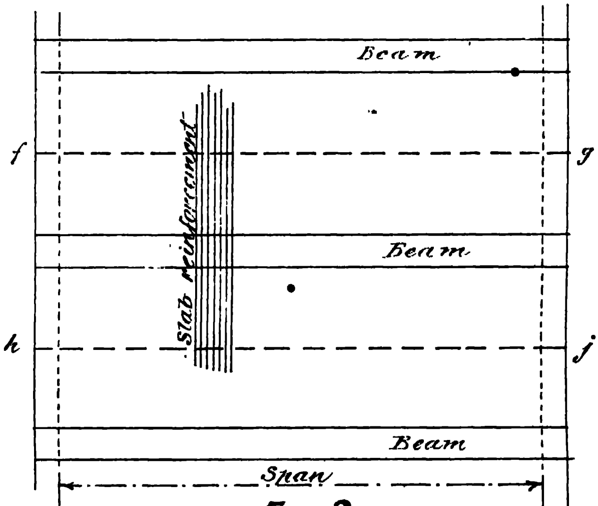


FIG. 2

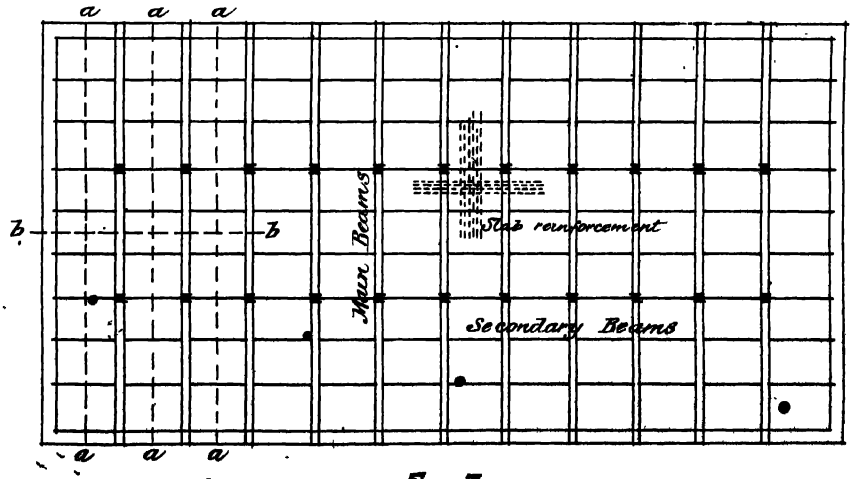


FIG. 3

strength being available. A temporary face board would be necessary to keep a vertical face of concrete to join up against on resuming. The upper part of

the slab being in compression the action under loading will be simply pressure on the two concrete faces, and the shearing stress at the joint will be *nil.*

In constructing larger floors where there are both main and secondary beams a somewhat similar method is desirable. For the purpose of illustration a floor has been assumed as in *Fig.* 3, where the main beams, supported at intervals by columns, run the short way of the building, and between the main beams are the secondary beams with a slab over all.

Here the main beams and column connections demand special notice, and from theoretical considerations the concreting would be most advantageously carried out in bays across the short way of the building, each bay comprising a main beam and portions of the attached secondary beams and slabs, the joint lines being along the centre lines of slabs and parallel to the main beams, as shown by the broken lines *a—a*. Complete homogeneity would thus be assured to the main beams and the portions of the slab acting therewith as a T-beam, there would be no break in the work over or around the column heads, and so far as the secondary beams are concerned the stopping planes would be in the most suitable positions—viz., at the centre of the span and at right angles to the direction of the beam.

Assuming, however, that the size of the building is such that the volume of concrete in one bay, as indicated, is too great to be put in without a break, it will be necessary in order to reduce the amount of work to be done in one operation to make stopping planes through the main beams. The first point then calling for notice is the necessity for avoiding a break at the points of inflexion (which are at approximately span from the supports) on account of the shearing action at such points. A stopping plane could most advantageously be made at the centre of middle span—*i.e.*, in the line *b—b*.

In no case should concreting be stopped in beams or slabs where shearing stress is likely to be great, as at a point near the supports or under a heavy concentrated load.

It is necessary to fix the whole of the reinforcement in beams before concreting is commenced, but in the case of slabs a common practice is to lay the bars down a few at a time as the concreting proceeds. The adoption of the stopping planes advocated above necessitates the fixing of the slab bars in advance of the concreting—a decided gain as regards accuracy of spacing and the ultimate strength of the work.

Columns.—In general, stopping planes in columns present no difficulty, as they are usually concreted for the full height between floors at one operation. Even if this does not occur, provided the concrete is temporarily left with a horizontal surface, and kept clean and free from foreign matter, no weakness is incurred, as the joint will be at right angles to the pressure upon it.

Arches.—The stopping planes in concreting arches may occur, according to the magnitude of the arch, either longitudinally or transversely. In each case both the upper and lower reinforcements should be placed and fixed securely in position prior to commencing concreting. Where possible a strip the full thickness of the arch should be concreted from abutment to abutment in one operation, the temporary joint being made against a profile erected on the

laggings in the case of longitudinal reinforcement only, or in the case of mesh reinforcement by short boards set vertically between the meshes, as shown in *Fig.* 4

In concreting sections of the arch transversely the stopping planes should

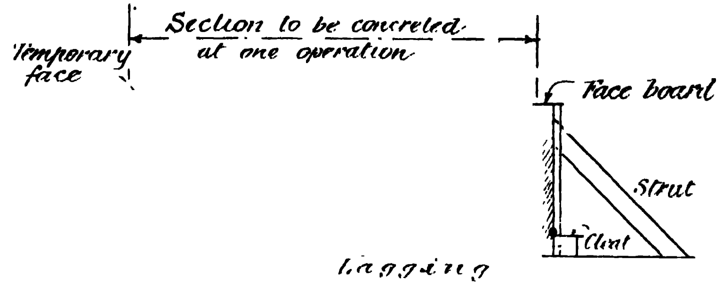


Fig 4.
STOPPING PLANES IN REINFORCED CONCRETE.

be at right angles to the line of pressure, or, for all practical purposes, perpendicular to the curve of the arch at the point, and, where possible, it is preferable to concrete a section the full width of the bridge at one operation. The temporary joint in this case will be made against a straight shutter of such depth as to be a very easy fit between the upper and lower reinforcement, such shutter being slipped in from the ends and temporarily secured at the proper angle. On recommencing, the shutter will be drawn out, the face boards fixed, and concreting proceeded with. The formation of a stopping plane of this description is shown in *Fig.* 5.

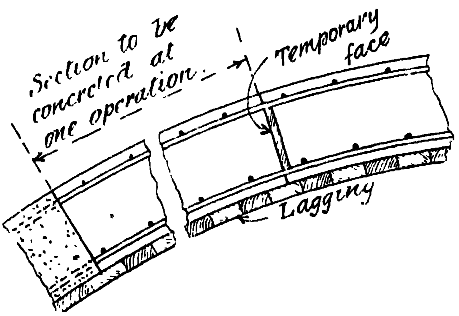
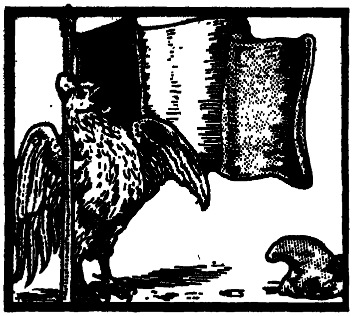


Fig. 5.
STOPPING PLANES IN REINFORCED CONCRETE.

By careful consideration beforehand the positions of stopping planes ought to be determined and then worked to. Too much emphasis cannot be laid upon the necessity for thoroughly cleaning, roughening, and laying thick grout upon all stopping plane surfaces when concreting is recommenced.



REINFORCED CONCRETE WHARF AND JETTY AT SAINT-LOUIS, SÉNÉGAL.

The following interesting article has been compiled for us by Mr. G. C. Workman, and is based on an article which appeared in the French Journal, "Génie Civil," by Mr. Alfred Jacobson, Civil Engineer (France).—ED.

THE important works described in this article, which have recently been completed, are of special interest on account of the fact that they were executed entirely by native African labour, under the supervision of a few French engineers.

The work comprises an extensive wharf on one side of the river Sénégal, and a quay or wharf continued as a jetty on the other side of the same river. The total length of these wharves, quays and jetties, altogether about 1,200 m., was entirely constructed in reinforced concrete on the Coignet System. The work was put in competition in December, 1910, among French contractors specialising in reinforced concrete. After careful consideration of the various schemes put forward, Mr. Merlaud-Ponty, Governor-General of the French West Coast of Africa, decided to entrust the execution of the work to Mr. Edmond Coignet, of Paris.

The contracts concerning the construction of the wharf and of the quay and jetty were respectively signed on April 22nd and December 1st, 1911.

As this work was to be executed by natives and in a distant country, Mr. Coignet thought it advisable to carry out the work in collaboration with Mr. G. Touzet, contractor at Dakar, the latter being already thoroughly acquainted with local conditions.

The wharf, which has been constructed for the accommodation of steamers, measures 242 m. in length, and has a total surface of about 3,000 sq. m.; 2,500 sq. m. of this total surface is constituted by a deck in reinforced concrete, and the remaining 500 sq. m. is constituted by a filling of earth at the back of a certain portion of the wharf. The work has been calculated to support a superload of 2,000 kilogs. per sq. m. The total length of the wharf is divided up into two different sections :—

1st. An upstream section of 110 m. in length, with a width of 13 m., in which the deck is supported on three rows of piles and upon a wall in masonry work already existing.

2nd. A downstream portion of 132 m. in length and 8·40 m. in width, in which the deck is supported by three longitudinal rows of piles. In this case the extra width of the wharf is made up by an embankment of earth retained by means of sheet piles, as shown in *Figs.* 2 and 3.

The reinforced concrete piles, of which there are 147, are spaced longitudinally every 5 m. and transversely every 4·11 m. centres in the upstream portion; and every 4 m. in the downstream portion of the wharf. The piles of the middle row have a diameter of 0·38 m. and those in the two lateral rows have a diameter of 0·33 m. These piles were driven down to a hard stratum situated at a depth varying between −12·50 m. and −14 m., the top of the deck being at a level of +1·80 m. The height of the various points of support therefore varies between 14 m. and 16 m.

The reinforced concrete deck is composed of a slab 0·10 m. in thickness, supported

by longitudinal beams having a span of 5 m. and scantlings of 0·16 × 0·30, the latter being supported by the piles, or by principal beams having scantlings of 0·33 × 0·45. Gussets were provided in order to contribute to the rigidity of the work.

Fig. 5 shows a detail of the reinforcement of the deck and of the arrangement of the beams. The reinforced concrete slab of the deck was covered by means of a pavement made by placing by hand pieces of very hard stone into a layer of rich concrete to a thickness of 0·10 m.

The reinforced concrete sheet piles acting as a retaining wall had a section of 0·12 × 0·33. They were fitted with tongue and groove. The sheet piles were driven 1 m. into the ground and fixed at their top into a longitudinal beam. As an extra

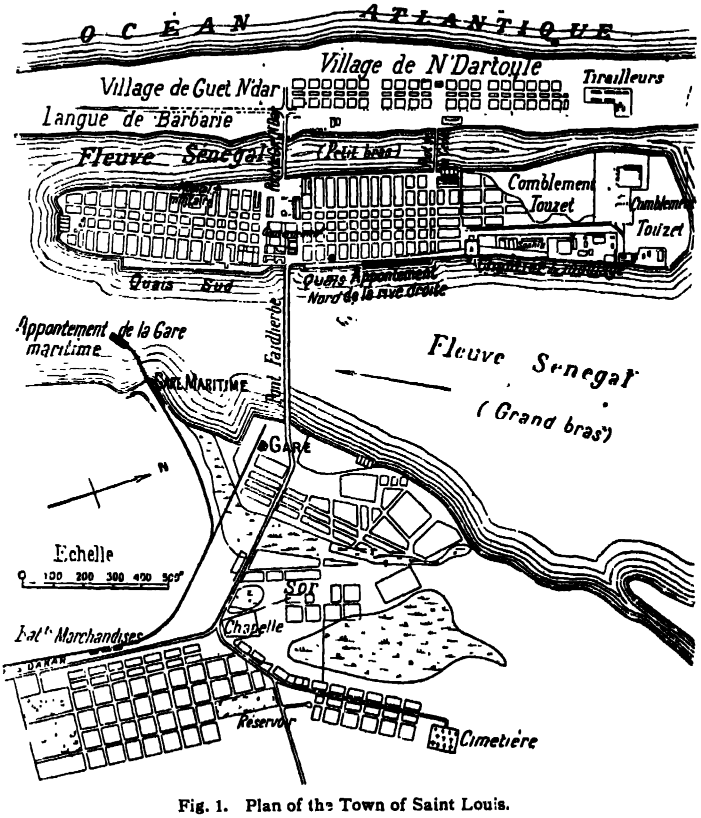
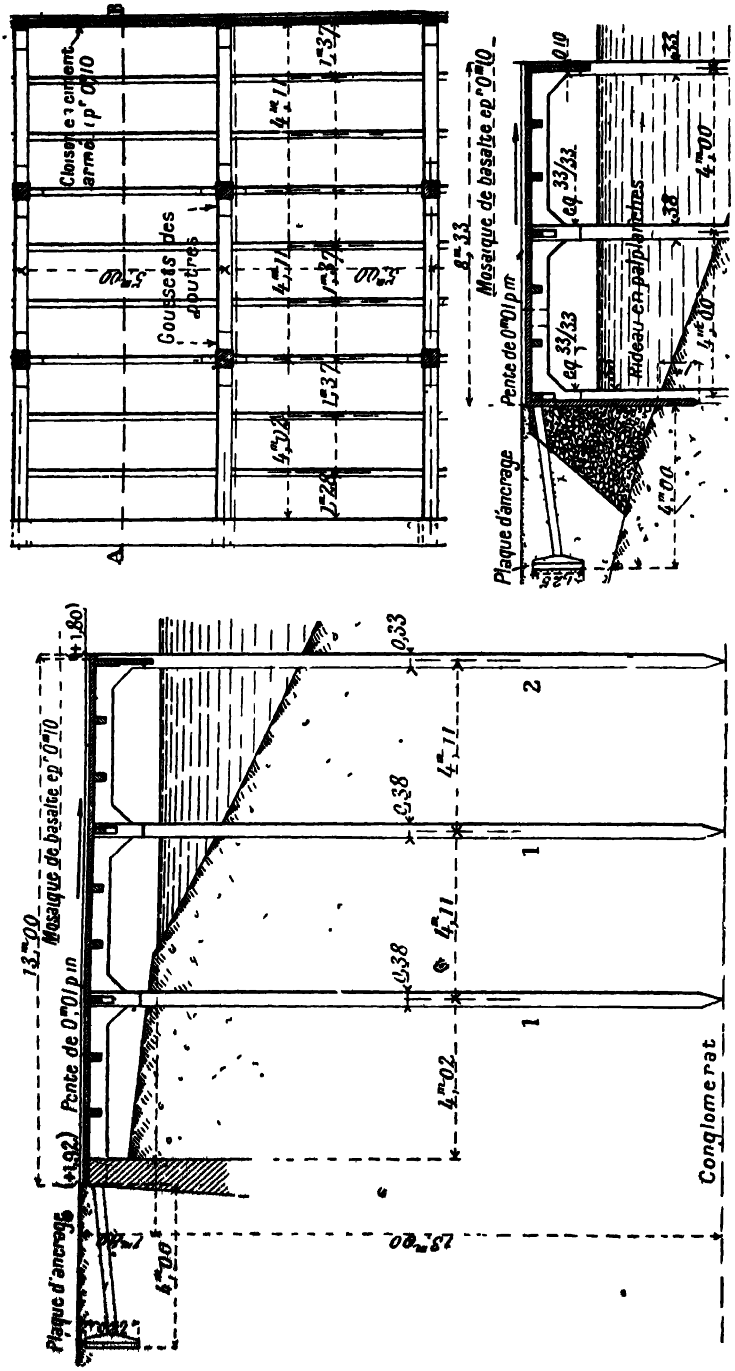


Fig. 1. Plan of the Town of Saint Louis.
REINFORCED CONCRETE WHARF AND JETTY, SAINT-LOUIS, SÉNÉGAL.

measure of precaution, every 5 m. in front of the principal beams land ties have been provided. These are covered in concrete and anchored at one end into the reinforced concrete deck and at the other into vertical reinforced concrete plates 1·25 m. by 1·25 m.

By looking at section No. 5 it will be seen that an apron 0·10 m. in thickness has been provided in front of the work, and between the front longitudinal piles. This is to prevent the small boats from going underneath the platform.

The jetty and wharf on the other side of the river near the railway station are composed of an approach of 140 m. in length and 3·65 m. in width, joined on to the end, which is designed for ships to come alongside, and which measures 60 m. in



FIGS 2 & 3 Transverse Section and Plan
REINFORCED CONCRETE WHARF AND JETTY SAINT LOUIS, SENEGAL

length and 10·33 m. in width. See *Figs.* 7 and 8. The total area of the wharf measures 1,300 sq. m.

The work has been calculated for a uniformly distributed load of 3,000 kgs. per sq. m.

Fig. 4. General View of Works on right bank of river during driving of piles.
REINFORCED CONCRETE WHARF AND JETTY, SAINT-LOUIS, SÉNÉGAL.

The 147 piles included in this work have been arranged at distances of 4 m. There are only two rows of piles in the approach and three or four in the wider part at each end of the jetty. These piles have a diameter of 0·33 m., except those in the middle portion where there are more than two rows of piles, where their diameter is 0·40 m. The slab of the deck is 0·10 m. in thickness, with way beams of 0·22 × 0·40 and secondary

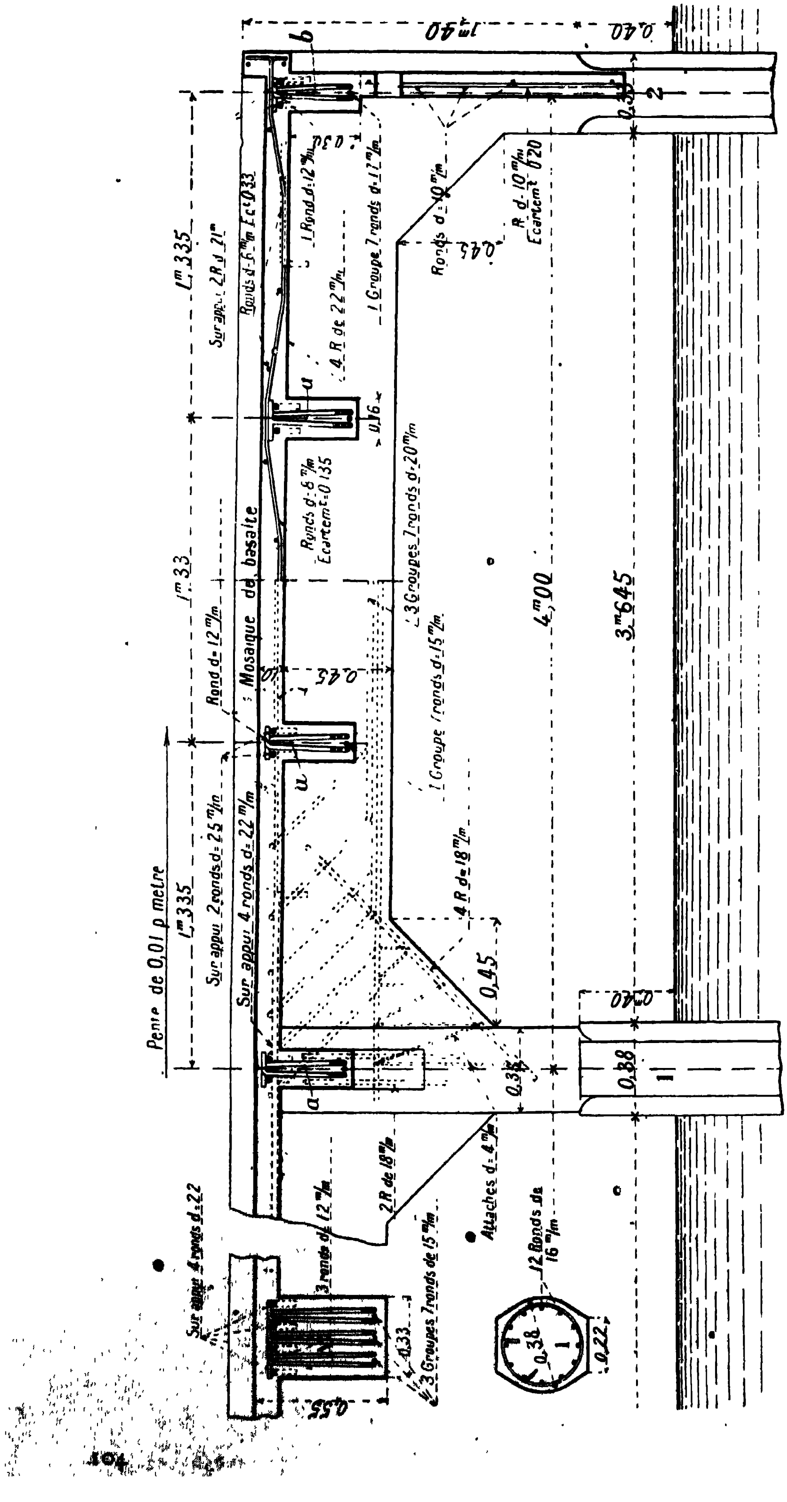


Fig. 5. Detail of Reinforcement of Deck and Arrangement of Beams.
Reinforced Concrete Wharf and Jetty, Saint-Louis, Sénégal.

.0·16 × 0·25. The transverse beams measure 0·33 × 0·50 and the braces uniting us piles measure 0·20 × 0·30.

he steel bars and the cement used in this work were sent from France. Local gravel, however, were used for the aggregate. The concrete was mixed by salt water taken from the river.

xecution of the work was divided into three parts :—

, the moulding of the piles, sheet piles, and anchor plates, and also the n of the braces for the jetty; secondly, the driving of the piles and sheet piles; rtmly the making *in situ* of the deck.

The first portion of the work mentioned above, comprising the moulding of piles, etc., is illustrated in *Figs.* 6 and 9, where natives are seen preparing the reinforcement of the piles and ramming the concrete into the moulds. The piles were left to mature

Fig. 6. View of Site for making Piles, and Natives making Framework for a Pile.
REINFORCED CONCRETE WHARF AND JETTY, SAINT-LOUIS, SÉNÉGAL.

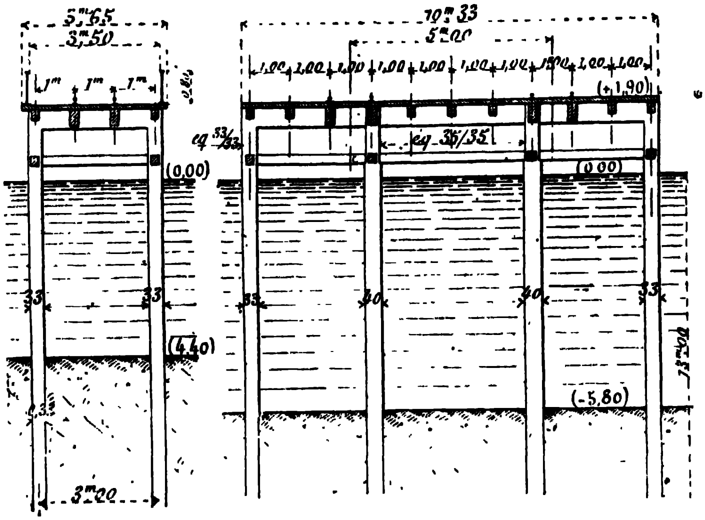
on the ground in the usual manner and steel moulds were used. It was usually possible to remove these at the end of 24 hours. After about a month the piles were loaded on a 50-ton steel barge, and they were taken on to the site of either the wharf or the jetty to be driven.

The work of driving the piles was carried out by means of a steam pile driver of the Decout-Lacour type. The position of the monkey was cantilevered at a distance of 5·60 m. from the wheels supporting the pile-driver, this weight being counterbalanced by the boiler at the other end of the structure. The total weight at the cantilevered extremity was 2 tons for the monkey and 5 tons for the pile during the pitching of the latter, giving a total of 7 tons to be counterbalanced by the weight of the boiler and any other counterweight required.

The peculiar arrangement of this pile-driving apparatus was necessitated by the fact that the reinforced concrete piles already driven were being made use of to drive

the ones in front. The pile-driving apparatus was capable of rotating upon an axis, and also of a longitudinal movement along rails, so that it was possible to pick up the piles from a barge lying alongside, to hoist them in the air, and pitch the pile in the required position for driving. The total height of the driving apparatus was 15 m. The total weight of the apparatus was 22 tons. As soon as a row of piles was driven the heads of these were connected together by means of wooden bracings, and a temporary platform was constructed upon which the pile-driving plant was shifted, in order to bring it into position for the driving of the next row.

A noticeable feature was that as soon as the braces were connected on to the new row of piles, the pile-driver was shifted in such a way as to bring its entire weight on two rows of piles. The apparatus would then pick up the beams of the deck at the back, and, turning round again, these beams would be placed on the top of the new piles which had just been driven. The platform or deck was then completed, and



Figs. 7 & 8. Transverse Section, left bank of river.
Reinforced Concrete Wharf and Jetty, Saint-Louis, Sénégal.

it was then easy to roll the bogeys into position at the centre of each bay, in order to distribute the weight of the pile-driving apparatus once more upon three rows of piles.

The advantage of this method of proceeding was found in the economy over a temporary staging, which would otherwise have been required, and the difficulties which there would have been in fixing such a staging in a sufficiently rigid manner to enable the handling and driving of these heavy piles in reinforced concrete without any danger.

Concerning the actual pitching and driving of the piles, this was carried out in the usual manner, the pile being lifted by the head.

When the piles were lifted at the head, the end resting on the ground, there was a total deflection in the middle equivalent to approximately the diameter of the pile—namely, for a pile of 14·20-m. length a deflection of as much as 0·33 m. was noticed. In each case, however, the pile regained its original straightness without showing any injuries, which is an example of the great flexibility of reinforced concrete.

The piles of 0·38-m. diameter of the middle row were driven with a 2-ton monkey

until they had reached a set of 0·01 for twenty blows of the monkey falling from a height of 0·25 m. The piles of 0·33 diameter of the lateral rows were driven to a set of 0·02 for twenty blows of the monkey falling from a height of 0·25. This set corresponds to the loads which the piles were calculated to support—namely, 60 tons for the piles 0·38 diameter and 32 tons for the piles 0·33 diameter.

Once the piles were driven the work of making the beams was proceeded with. The slab, however, was not constructed immediately after the beams, which is the usual practice, but about a fortnight later. In this manner it was possible to utilise

Fig. 9. Natives Concreting a Pile.
REINFORCED CONCRETE WHARF AND JETTY, SAINT-LOUIS, SÉNÉGAL.

the cheeks of the beams to support the centering of the slabs and the weight of the latter during the concreting. This method of procedure enabled the contractors to use comparatively light scantlings for the woodwork of the centering.

As shown in *Fig.* 10 the transverse braces for the heads of the piles, which had already been placed in position for the proper supporting of the pile-driving apparatus, were left in position and actually formed the centering for the transverse beams, so that the fixing together of the heads of each row of three piles served not only for the

purpose of steadying the piles to support the pile-driver, but also as a centering and staging for making cross-beams and supporting the deck during the construction.

Concerning the reinforcement of the beams and slabs, this is clearly shown in *Fig.* 5, where it will be seen that the beams are composed of a group of round bars. These bars have their ends gradually bent up at an angle of 45° and hooked to a longitudinal top bar, the advantage of this method being that the ends of the bars, which are no longer required to counteract the gradually decreasing bending moment, are made use of to counteract the gradually increasing shear towards the points of support.

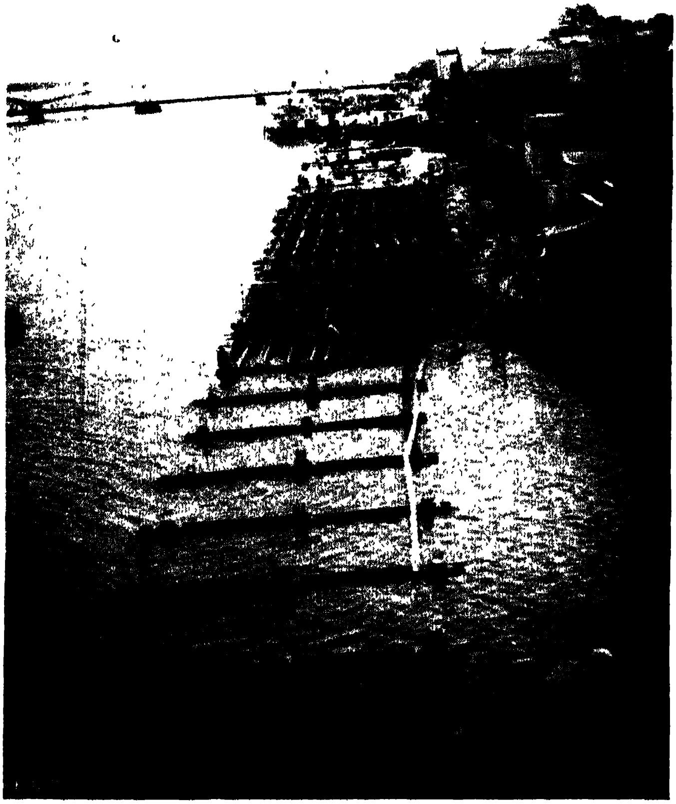
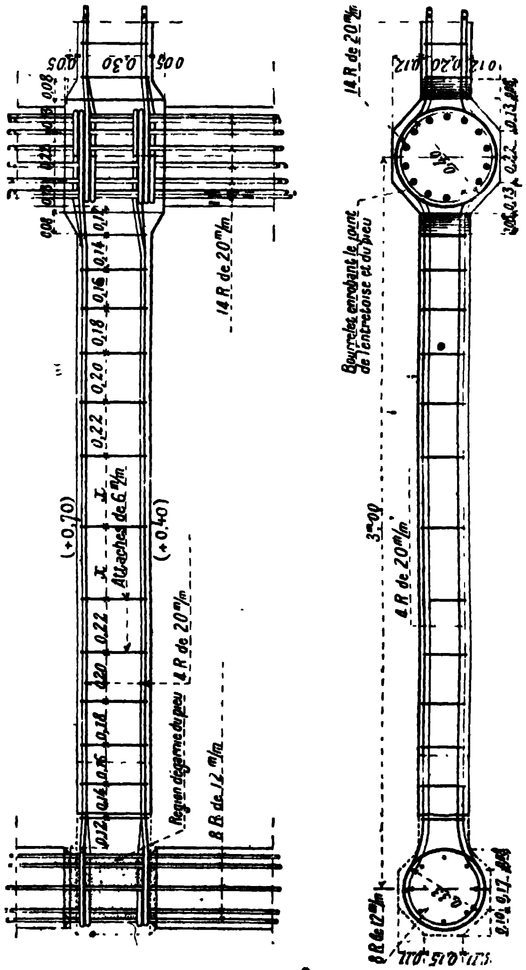


Fig. 10. General View of Wharf, right bank of river, during execution.
Reinforced Concrete Wharf and Jetty, Saint-Louis, Sénégal.

The frameworks or units of these beams were prepared beforehand by the natives and brought into position and simply hung into the casings. The system here adopted has been found specially suitable where native and unskilled labour has to be employed, because it has the advantages that once the unit reinforcement is prepared separately and beforehand, all that is necessary is to suspend it in the moulds during the concreting operation, and all the bars being bound together tightly, they cannot easily get out of position during the ramming of the concrete.

The framework of the slabs of the deck was simply composed of a meshwork of principal and secondary bars.

Concerning the jetty and the wharf alongside of same, these were constructed in a somewhat different manner from the principal wharf already described. The jetty was constructed by first driving the piles in the usual manner and by fixing the walings constructed beforehand in the manner shown in *Figs.* 11 and 12. This arrangement consisted in chipping off the concrete at the required level around the piles, and fixing the bars of the walings around the chipped portion in the manner shown in the drawing. The joint was then grouted up. In this manner it was possible to drive the piles to their full height without having to make the walings and uprights *in situ*. The variations of temperature during the day were between 30° and 40° Centigrade in the sun. During the periods of wind coming from the desert the temperature, however, was much higher. It was necessary, of course, to protect the work against this considerable heat, and for this purpose the concrete was covered over with a layer of sand of 1 or 2 cm., almost immediately after the concrete was placed in position. This sand was kept continually in a moist state until the concrete was at least twenty days old. This simple precaution was found to be quite sufficient to protect the work from the heat of the sun.



Figs. 11 & 12. Elevation and Plan of a Beam on left bank.
Reinforced Concrete Wharf and Jetty, Saint-Louis, Sénégal.

Concerning the labour, the men employed on the reinforced concrete work, either for the preparation of the steel frameworks, the centering, the concreting or the handling and driving of the piles, were all natives, very few of whom had any other trade but the loading and unloading of barges on the river. The method employed for carrying out the work was to form a certain number of gangs, the members of which were recruited by a few of the more intelligent natives, some of whom had a knowledge of carpentry, or who were already accustomed to direct the men in the loading and unloading of the barges. It was found that under the direction of these chief gangers the work proceeded in a satisfactory manner, and, although in certain cases the native labourers had only recently come from the interior of the country and were not accus-

tomed to any special kind of work, they very soon understood what was required, and were able to carry out their work as effectively as the others.

Fig. 13. Preparation of Centering for Deck of Wharf, right bank.
REINFORCED CONCRETE WHARF AND JETTY, SAINT-LOUIS, SÉNÉGAL.

Fig. 14. Wharf Partly Completed, right bank of river.
REINFORCED CONCRETE WHARF AND JETTY, SAINT-LOUIS, SÉNÉGAL.

Concerning the progress of the work, the 147 piles of the main wharf were driven between November 25th, 1911, and March 25th, 1912—namely, in four months. The area of 2,500 sq. m. of deck was executed between February 10th, 1912, and April 25th, 1912—namely, in two and a half months. Seeing that the manufacture of the piles was begun before November, 1911, and that the execution of the final pavement on the deck was finished after April, 1912, it may be stated in conclusion that the main work of this wharf was carried out between November 25th, 1911, and April 25th, 1912—namely, five months, which, taking into account the difficult nature of this kind of work in any case, the local conditions and the native labour, shows that reinforced concrete is eminently suitable for structures of this kind in the colonies.

The work of the various wharves and jetties was executed under the control of the Administration of Public Works in Sénégal, represented by Mr. Guyot, Chief Engineer, and Mesrs. Michas and Rolly, Assistant Engineers, and Mr. Roumégoux, Inspector.

Fig. 15. Concreting on Deck of Wharf, left bank of river.
REINFORCED CONCRETE WHARF AND JETTY, SAINT-LOUIS, SÉNÉGAL.

IMPERMEABILITY TESTS ON CONCRETE.

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The following tests were made by the author when he was in charge of the Laboratory of the New York City Board of Water Supply, in connection with the design of the Catskill Aqueduct. The results were later incorporated in a thesis submitted to the University of Vermont and the present abstract takes up in order the effect upon the permeability of concrete of the inclusion of hydrated lime, puzzolana, clay, very fine cement and additional cement, and in addition gives some new figures on the variation with the pressure of leakage through concrete. This article is reprinted from the American Journal, "Engineering News." - ED.

THE use of hydrated lime as a means of rendering concrete structures impervious to water has received the attention of several investigators, whose experiments have generally shown favourable results from its use. Engineers have employed this material in waterproofing reservoirs and tanks and have secured watertight structures.

The tests described below were undertaken with a view to determining the merits of this material and also puzzolan cement made by grinding together a mixture of blast-furnace slag and lime. Two brands of hydrated lime were used, a high calcium and a magnesian lime, each being a high-grade representative of its class. A single brand of puzzolan cement was used.

The tests were based for ready comparison on plain concrete in proportions 1 : 3 : 6 by weight. A lean mix was adopted to insure measurable leakage of the blanks. The increasing proportions of cementing materials used are given in the tables as fractions of the basal proportions of cement in order to show in an elementary manner the scheme adopted. The aggregates used were ordinary quartz sand and gravel supplied from Long Island banks for the New York market. The sand all passed a sieve with 0·2-in. square openings. The gravel passed the 1·75 in. and was retained on the 0·2-in. sieve. The density as well as the strength and permeability of the various mixtures was investigated.

The density test is becoming one of the recognised means of determining the properties of mortar and concrete. The density of concrete is defined as the ratio of the sum of the volumes of the solid particles, cement, sand and stone in the mix to the total volume of set concrete. It is the complement of the air and water voids. The methods of determining density will not be given here. (See "The Laws of Proportioning Concrete," by William B. Fuller and Sanford E. Thompson, *Transactions* Am.Soc.C.E., Vol. LIX.)

The permeability test specimens were cylindrical, 8 in. in diameter and 6 in. in length. About two weeks before testing the specimens were chipped with chisel and hammer to remove the "skin" and were enclosed over the sides and one end by neat cement casings poured around and over the specimens which were centered in circular moulds 12 in. in diameter. A pipe connection extended through the casing in line with the axis of the cylinder and terminated in a cushion of coarse, washed sand 1 in. in thickness, covering the end of the specimen. This sand cushion prevented the neat cement paste with which the casings were made from coating the end of the specimen and permitted the water to act over the full end area. The specimens being coupled to vertical outlets from the bottom of a pressure tank, the water was forced to traverse the entire thickness of the concrete and was caught and weighed as it dripped from the exposed ends. The leakage recorded is the total weight passing during the last 10-min. period of the 1-hr. test. Previous studies have shown that fairly uniform conditions

of flow are established within the hour when testing under the pressures used, 40 and 80 lb. per sq. in. The strength specimens were cylindrical, 6 in. in diameter and 12 in. in length. The tests were made on a 100,000-lb. screw-power testing machine, the crushing tool being fitted with a spherical bearing. The specimens were cushioned top and bottom with two thicknesses of blotting-paper.

In the tabulated results several minor inconsistencies appear. To maintain comparable conditions throughout a series of concrete tests is a difficult matter. Both permeability and strength tests are greatly affected by slight excesses or deficiencies in the amount of mixing water used. The required amount of water varies with the brand of cement and its degree of fineness, the fineness of the aggregate and other factors. Final determination of the proportion of water depends in some measure on the judgment of the operator. Under 40-lb. per sq. in. water-pressure Portland cement concrete in proportions 1·2 : 3 : 6, or richer, and all proportions of hydrated lime used give impervious concrete. Puzzolan cement in proportions 1·3 : 3 : 6, or richer, gives nearly impervious concrete.

At 80-lb. pressure several of the above described mixes are practically impervious, and none of them give much leakage.

High calcium lime is the only material giving entirely consistent results in decreasing permeability in proportion to the amount used. It is possible the richest proportions of magnesian lime and puzzolan cement were too dry for best results. (See tabulated percentages of water in Table I.) Averaging all comparable proportions the relative strengths at 3 mo. age are as follows:

Portland cement.	Calcium lime.	Magnesian lime.	Puzzolan cement.
100 per cent.	85 per cent.	76 per cent.	81 per cent.

The density tests show unexpectedly uniform results throughout the series. Hydrated lime alone yields about 2¼ times the volume of paste that an equal weight of Portland cement does. A record of the volumes of rammed concrete produced in the tests was kept as a check on the volume computed from the density tests.

Comparison of volumes as tabulated is based on the volume of the plain concrete as a unit. The lime does not have an appreciable effect in increasing the volume of concrete; neither does it increase the density. The result is an apparent paradox. Tests on the richest cement-lime paste used in comparison with cement paste showed the cement-lime mixture gave an increase in volume of paste of 29 per cent. over plain cement paste. The density of this paste was 0·42. It was, therefore, very porous and must have contained a large amount of free water. The density of the plain cement paste was 0·52.

Comparison of the relative volumes of solid particles in the two pastes resulting from equal weights of dry materials is made as follows:

Volume of cement-lime paste equals 129 per cent. of cement paste.

$1·00 \times 0·52 = 0·52 =$ relative total volume of solid particles in cement paste.

$1·29 \times 0·42 = 0·54 =$ relative total volume of solid particles in cement-lime paste.

The reason for the failure of the lime to produce measurably denser concrete thus becomes evident. The low density resulting offsets the increased volume over cement paste. Comparison of the density computations, not here given, showed that a smaller volume of air was entrained in the concrete where lime was used. The failure of the lime to give an increased total volume of concrete was due to the replacement of free water and entrained air in the plain concrete by the porous, water-filled, cement-lime paste. This paste simply occupied space which in the plain concrete was filled with water and air, and therefore no appreciable increase in gross volume resulted.

This latter result suggests that the use of this mixture of cement and lime should give superior water-resisting concrete by filling the larger interstices between the particles of aggregate with this paste. While this paste will not reduce the total percentage of voids in the mass, it will fill the comparatively large-sized pores—through which water can pass quite readily—with this fine-pored substance, thus offering much resistance to flow.

The permeability tests here given bear out this deduction to some extent, particularly in the tests at 40 lb. pressure. The practical advantage does not, however, appear from these tests to be sufficient to merit much consideration.

With cement-lime paste, the maximum density any paste-filled cavity can have is 0·42; with cement paste it may be 0·52.

Tests by other experimenters, as well as other tests by the writer, have shown the density of cement paste to average about 0·60 for pastes of ordinary consistency. Using this value, the merits of this cement-lime paste compare less favourably than above.

Based on prices in New York markets, plain Portland cement concrete costs slightly less per cubic yard for materials than any of the other mixes containing equal proportions of cementing materials. For equal efficiency in waterproofing at 40 lb. pressure the use of hydrated lime reduced the cost of materials about 5c. per cubic yard of concrete.

Puzzolan cement was at a disadvantage in this comparison on account of the remoteness of the mill from New York and the consequent high freight charge.

Conclusions.—(1) Hydrated lime is effective in producing impervious concrete, but its use is doubtful economy, except, possibly, for resisting low pressure of water. Concrete in proportions 1 : 3 : 6 requires the addition of a proportion of lime equal to about 20 per cent. of the weight of the cement for efficiency against high pressure. This results in a slight loss in the compressive strength of the concrete as compared with the plain 1 : 3 : 6 mixture.

(2) It is probable it is not an economical material for structures subjected to tensile stress, such as reinforced conduits.

(3) Except possibly for low pressures, equally good results in impermeability can be obtained by the same cost invested in additional cement, with resulting stronger concrete.

(4) The addition of lime increases the plasticity and mould-filling properties of concrete, resulting in smoother surfaces against forms. Its use may give practical advantages in filling around reinforcing steel and in other restricted spaces.

TABLE I.—Permeability and Strength Tests of Concrete, Effect of Hydrated Lime and Puzzolan Cement

Cement.	Proportions by weight.	Leakage in grams. Pressure, 40 lb.	Leakage in grams. Pressure, 80 lb.	Comparative strength, 28 days.	Lb. per sq. in., 3 months.	Comparative yield, volume.	Density.	Water, per cent.	Cost of material per cu. yd.
									$
Group A: Portland only	1 : 3 : 6	6	47	745	1,535	1·000	0·857	7·8	3·513
	1·1 : 3 : 6	33	77	650	1,180	1·035	0·812	8·4	3·512
	1·2 : 3 : 6	0	2	920	1,860	1·045	0·788	8·3	3·608
	1·3 : 3 : 6	0	0	910	2,000	1·069	0·805	8·5	3·633
	1·4 : 3 : 6	0	18	1,070	1,950	1·069	0·790	8·7	3·769
Group B: Portland and high calcium lime	1·1 : 3 : 6	0	20	800	1,615	1·032	0·816	8·0	3·563
	1·2 : 3 : 6	0	12	680	1,320	1·038	0·804	8·7	3·679
	1·3 : 3 : 6	0	0	595	1,330	1·069	0·793	9·3	3·704
Group C: Portland and magnesian lime	1·1 : 3 : 6	0	4	475	830	1·038	0·789	9·1	3·553
	1·2 : 3 : 6	0	0	765	1,460	1·069	0·793	8·8	3·617
	1·3 : 3 : 6	0	14	760	1,545	1·069	0·789	8·8	3·794
Group D: Puzzolan only	1 : 3 : 6	5	22	600	880	1·006	0·822	7·6	3·642
	1·1 : 3 : 6	13	25	490	1,415	1·017	0·833	8·0	3·747
	1·2 : 3 : 6	7	45	580	1,345	1·030	0·798	7·8	3·841
	1·3 : 3 : 6	0	0	620	1,305	1·028	0·784	7·9	3·974
	1·4 : 3 : 6	0	6	910	1,505	1·075	0·817	7·7	3·949

The fractional parts in cement column of Group A are excess Portland cement; in Group B, calcium lime; in Group C, magnesian lime; and in Group D, excess puzzolan cement.

Permeability specimens, cylinders 8-in. diameter, 6 in. in length. Tested at 40 lb. pressure per sq. in. for one hour, then at 80 lb. one hour without interruption. Three specimens in each average.

Portland cement; tensile strength, 1 : 3 Ottawa sand, 28 days, 306 lb. per sq. in., sp. gr. 3·16, Thru No. 200-mesh sieve, 80·5 per cent.

Puzzolan cement; tensile strength, 1 : 3 quartz sand, 28 days, 146 lb. per sq. in., sp. gr. 2·90, Thru No. 200-mesh sieve, 95·8 per cent.

Compressive specimens, cylinders 6-in. diameter, 12 in. in length, 28 day tests on one specimen usually.

Three months tests the average of three specimens in all cases. Permeability tests made at 28 days age.

Quoted prices in New York, per ton: Sand, $1.08; gravel, $1.40; Portland cement, $6.78; Puzzolan cement, $7.60 high calcium hydrated lime, $8.00; magnesian hydrated lime, $9.50.

(5) Puzzolan cement is slightly less efficient than the cement-hydrated lime construction. In this comparison the puzzolan cement is at an economic disadvantage because of the long freight haul.

CLAY IN CONCRETE.

The object of the tests was to compare the effect of clay in reducing permeability with the effect of equivalent weights of extra cement.

The clay used was a white, pure clay from Georgia, intended to represent high-grade material in colloidal properties. Approximate quotations of prices, delivered in New York, gave the cost as very nearly equal to that of Portland cement, weight for weight. The tests, therefore, afford a direct comparison of costs of the two processes of waterproofing, assuming that the use of clay involves no extra cost in mixing the concrete.

Plain concrete of two percentages of cement, 10 per cent. and 11 per cent., were selected as the basis of the tests, the total percentages of fine material in the dry mix, 45 per cent., remaining constant. The percentages of clay used were based on the weight of the sand and replaced the stated percentages directly by weight. The percentages of clay selected were 5, 7·5, and 10 per cent. For comparison, a series of specimens was made in which extra cement replaced the stated percentages of sand in the same manner as the clay; also blanks or specimens containing no clay or extra cement.

The casings of neat cement in which the specimens were enclosed for testing were not as perfect as are usually secured, and permitted a small leakage between casing and specimen in a few instances. The water appeared at the edges of the specimens and could not be separated from that coming through the concrete. In tabulating the results these defective specimens, as determined by the judgment of the observer, were omitted.

Table II. shows, as in previous tests with clay, a marked decrease in permeability over plain concrete, but as compared with the extra cement there is no practical advantage. Both processes give impervious concrete at 80 lb. pressure. It is of practical value to note that the concrete of ordinary sand and gravel containing 13·5 per cent. cement was impervious at a pressure corresponding to 185 ft. head of water.

TABLE II.—PERMEABILITY AND STRENGTH TESTS OF CONCRETE, EFFECT OF CLAY.

—	Proportion by weight.				Clay, per cent.	Leakage in grams.		Comparative strength, lb. per sq. in.	Density.	Water, per cent.
	Cement.	Clay.	Sand.	Gravel.		Pressure, 40 lb.	Pressure, 80 lb.			
Group A ..	1	0	3·50	5·50	0	6	73	770	0·789	9·3
	1	0·18	3·32	5·50	5	0	3	910	0·782	8·1
	1	0·26	3·24	5·50	7·5	4	9	1,110	0·768	9·6
	1	0·35	3·15	5·50	10	0	0	945	0·770	9·2
Group B ..	1.18	0	3·32	5·50		0	2	1,130	0·807	7·9
	1·26	0	3·24	5·50		3	10	1,290	0·800	8·3
	1·35	0	3·15	5·50		0	0	1,265	0·780	9·2
Group C ..	1·1	0	3·40	5·50	0	37	128	800	0·775	9·7
	1·1	0·17	3·23	5·50	5	0	0	880	0·780	9·3
	1·1	0·26	3·14	5·50	7·5	0	0	905	0·772	9·3
	1·1	0·34	3·06	5·50	10	0	Trace	905	0·777	9·8
Group D ..	1·26	0	3·24	5·50		3	10	1,290	0·800	8·3
	1·35	0	3·15	5·50		0	0	1,265	0·780	9·2
	1·44	0	3·06	5·50		Trace	17	1,395	0·791	10·4

Sand, Cow Bay passing 0·2-in. sieve: gravel, Cow Bay. between 1·75 and 0·2-in. sieves.
Portland cement; tensile strength, 1 : 3 Ottawa sand, 28 days, 329 lb. per sq. in., sp. gr. 3·18, Thru No. 200-mesh sieve, 76 per cent.
White Georgia clay passing No. 30 sieve.
Compare Group A with B, C with D, Groups A and B based on 10 per cent. of cement, Groups C and D on 11 per cent. of cement. Clay replaces stated percentages of sand based on the blank. Age at testing, 28 days. Duration of permeability test one hour at each pressure. Leakage reported for last 10 min. Three specimens in each average usually. Specimens cylinders 8 in. in diameter, 6 in. in length. Compressive specimens, cylinders 6 in. in diameter, 12 in. in length. One specimen in each test.

There is a trivial discrepancy, 0·01 per cent., in the percentages of excess cement in two of the tests in group D as compared with the percentages of clay in the corresponding tests in group C. It will be observed these tests in group D were brought down from group B; these specimens, containing so nearly the right percentages of cement that new tests were not required for comparison with group C.

Density.—The clay slightly decreased the density in the 10 per cent. concrete, and slightly increased it in the 11 per cent. concrete. The excess cement slightly increased

TABLE III.—PERMEABILITY TESTS OF MORTAR, EFFECT OF VERY FINE CEMENT.

Brand No.	Leakage in grams.				Fineness.		Specific gravity.	
	Normal pressure, 40 lb.	Cement pressure, 80 lb.	Sifted pressure, 40 lb.	Cement pressure. 80 lb.	Sieve 100.	Number 200.	Normal.	Sifted.
1*	3	22	3	33	96·5	79·8	2·16	3·13
2		25		2	93·5	74·6	3·17	3·13
3		29		Trace	97·6	89·2	3·08	3·05
4		331		81	94·7	84·9	3·16	3·14
5		27		Trace	92·3	78·9	3·13	3·12
6		31		2	91·3	79·4	3·14	3·11
7		5		0	95·4	75·0	3·19	3·17
8		6		Trace	95·3	81·0	3·18	3·16
9		71		0	91·0	73·0	3·10	3·09

* Retained on No. 200 sieve, 2,163 grams leakage at 40 lb. pressure.
Proportions 1 : 4 by weight. Sand, Cow Bay graded so as to be permeable.
Age, 28 days. Duration of test one hour. Leakage reported for last 10 min.
Specimens, 2-in. cubes enclosed in neat cement casings.
Five or six specimens in each average, except for brand No. 7, in which three specimens were used. Temperature of water 63° to 68° F.

the density in both the 10 and 11 per cent. concrete, with the exception of the 10 per cent. increase in the 10 per cent. concrete. The maximum increase with both the 10 and 11 per cent. concrete was with 5 per cent. excess cement.

Strength.—Strength was tested only incidentally, the material used for the density tests being utilised to produce a single 6 x 12 in. compression cylinder of each mix for testing at 28 days' age. The clay gives increased strength over the blanks, but a smaller increase in all cases than the corresponding excess of cement.

It is noticeable that the clay gives better results in the leaner concrete. This seems to indicate that the clay acts simply in a manner similar to ordinary very fine aggregate, for it is well known that lean concretes are benefited in strength by the addition of fine material, such as loam and dust, while rich concretes are not.

Notes on Clay.—It should be remembered that these comparisons are based on the assumption that no extra cost in mixing the concrete is involved in the use of the clay. This assumption is undoubtedly in favour of the clay, as special appliances for introducing it would be necessary. In these tests the clay, which was in a comparatively dry and lumpy condition, was pulverised and sifted to pass a No. 30 sieve. Fifty-four per cent. passed the No. 100, and 15 per cent. the No. 200 sieve. Should it be found necessary to adopt this method in practice, the process would involve considerable expense. A less expensive method, if found practicable, would be to add the clay to the mixing water.

Should it be found that common brick clay would serve the purpose, this material could be obtained for about $3 per ton, or about three-eighths the cost of cement. This advantage would be partially offset by the mechanically combined water in the clay. Clay as taken from the bank ordinarily contains 20 to 40 per cent. of

TABLE IV.—PERMEABILITY TESTS OF CONCRETE, VARIATION OF LEAKAGE WITH PRESSURE.

Sand.	Stone.	Proportions by weight.	Pressure and leakage.					Ratio of leakages.			
			20.	40.	60.	80.	100.	40-20.	60-20.	80-20.	100-20.
Cow Bay ..	Limestone 1·75-0·2 in.	3·50 : 5·83	3	6	13	23		2·00	4·33	7·67	
Cow Bay ..	Gneiss 1·50-1·0 in.	3·50 : 5·66	5	19	35	47		3·8	7·00	9·40	
Cow Bay ..	Gneiss 1·50-0·2 in.	3·50 : 5·66	19	64	109	157		2·21	3·76	5·42	7·07
Crushed Gneiss	Gneiss 1·50-0·2 in.	3·60 : 5·66	55	126	220	361		2·29	4·00	6·57	9·02
Cow Bay ..	Gravel 1·75-0·2 in.	3·50 : 5·50	14	27	51	80		1·93	3·64	5·72	9·44
Shale and Cow Bay	Shale 1·75-0·2 in.	3·53 : 5·72	14	22	48	80		1·59	3·43	5·71	
Average								2·30	4·36	6·75	8·51

Specimens cylinders, 8 in. diameter, 6 in. length.
Age at testing, [illegible] days.
Cement, Portland, 81 per cent. passing No. 200 sieve.
All sand passed a 0·2-in. sieve.
Pressures in lb. per sq. in.

mechanically combined water. This amount can be greatly reduced by air drying, but clay is very hygroscopic and may absorb as much as 10 per cent. of its weight of water from the atmosphere.

Conclusions.—(1) Clay added to ordinary concrete gives beneficial results in permeability and strength, with no practical effect in density.

(2) Compared with an equal excess of cement by weight, clay gives no advantage of practical importance in permeability or density, and results in a loss in strength.

(3) Both processes give impermeable concrete under 80 lb. pressure.

(4) If the use of clay is practicable on a working scale, its possible economic use under two methods is evident:

(*a*) By mixing with the cement at the cement mill. The mixed material would have to be sold about 20 per cent. cheaper than ordinary cement.

(*b*) By mixing in the field in localities where the cost of cement is high and clay can be obtained very cheaply.

Subsequently to the above tests another series was made in which blue New York brick clay was substituted for the white Georgia clay. The results confirm the earlier tests.

EFFECT OF VERY FINE CEMENT.

Tests on mortar specimens were made using cement in its normal condition, parallel tests being made using portions of the same samples of cement sifted through the No. 200 sieve. A single test was made using the residue on the sieve. Nine well known brands comprised the series.

The marked decrease in permeability, as shown by the accompanying Table III., resulting from the sifted cement shows that as in strength so in permeability the finer particles only are efficient. Extremely fine grinding may be of even more importance for its effect on impermeability than on strength.

ADDED CEMENT AS A FILLER.

The writer designates such finely divided materials as hydrated lime, clay, puzzolan cement, sand cement and very fine sand, for want of a more scientific name, as pore fillers. The preceding and other tests not described here have demonstrated that such substances may be used to produce highly impermeable concrete. The same result can, however, be obtained by the use of an extra amount of Portland cement, at less cost usually than by any of the special materials, and in all cases with an increase in the strength of the concrete over the other materials. For impermeable construction concrete should contain not less than 45 per cent. of combined fine aggregate and cement. With ordinary aggregates 15 to 18 per cent. of the entire dry mixture should be cement unless the resisting walls are several feet in thickness.

In all the preceding tests the smooth top and bottom surfaces of the specimens were chipped off. The surface formed against smooth forms is very highly effective against permeability if unbroken. Offsetting this important matter in practical work we have the usual necessity of depositing the concrete in successive layers with the possible attendant formation of planes of stratification parallel to the water pressure. Leakage in this direction, unless the concrete is of such a wet mixture and the construction so continuous as to prevent the formation of such planes, may be many times greater than that due to perpendicular pressure. In one test on 1 : 2·7 : 6·3 concrete the excess of leakage parallel to the bedding planes was 70 per cent.

VARIATION OF LEAKAGE WITH PRESSURE.

In this series the aggregates included quartz gravel, crushed limestone, gneiss and shale.

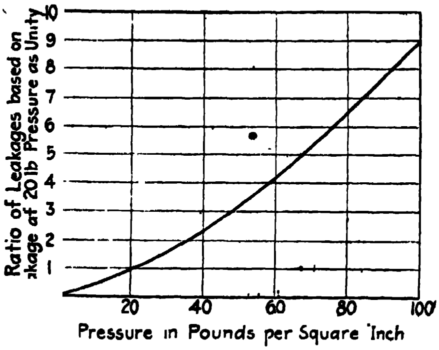
The fine aggregates included both natural silicious sand and screenings from the coarse aggregates. In one set a half and a half mixture of natural sand and screenings was used.

The series, therefore, represents a wide range in materials. Each of the six sets consisted of three specimens. Nearly every specimen was tested at each of the five pressures. The specimens constituted the blanks from a larger series of permeability tests made at 40 and 80 lb. pressure in which certain chemicals were investigated for their waterproofing properties. It is unnecessary to describe the larger series here.

The present tests were made by subjecting the specimens to a second series of pressures of greater range than the original pressures. Following the first tests the specimens were allowed to drain about 2 hours. Pressure of 20 lb. was then applied and raised to 40, 60, 80 and 100 lb. at 30-min. intervals. The total leakage for the last 10 min. of each period is used in this study.

Observations early in the tests showed that for this series fairly uniform rates of leakage were established within 30 min. after pressure was applied.

The average results on each set of three specimens are given in Table IV., and averages for the entire series by the accompanying curve.

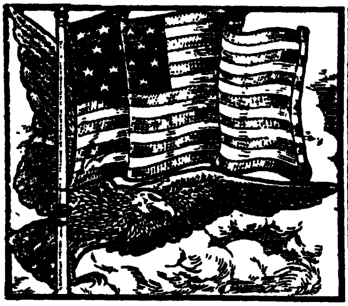


VARIATION OF LEAKAGE THROUGH CONCRETE WITH PRESSURE.

The range in pressure was sufficient to cover all heads up to 230 ft. The general conclusion is reached that leakage increases more rapidly than pressure. In any practical case, having the leakage determined by a test within the range of pressures given above, the leakage at any other pressure may be estimated by referring to the curve.

Lean concrete was used in order to insure measurable rates of leakage throughout the series.

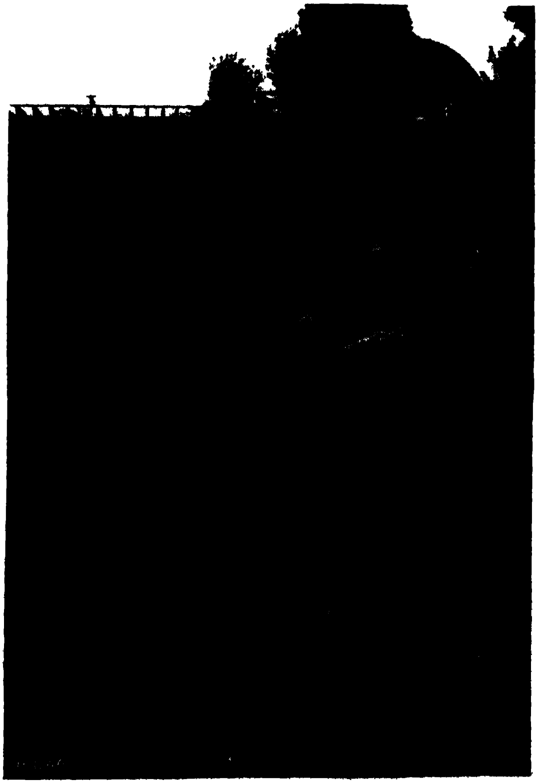
The leakage was higher in this series of tests than in the original tests on the same specimens. The average increase for the eighteen specimens was 29 per cent. at 40 lb. and 12 per cent. at 80 lb. pressure. This indicates that raising the pressure enlarges the water passages. It is probable that under continued action the rate of leakage would decrease in the usual manner.



THE USE OF CONCRETE FOR ORNAMENTATION IN AMERICA.

That concrete can be successfully applied for ornamental use in public parks, gardens, etc., will be seen from the subjoined particulars of some works carried out for the municipality of Chicago. We are indebted to "Concrete Cement Age," U.S.A., for our illustrations and details, abstracted from an article by Mr. Marc. N. Goodnow. —ED.

IN the laying out of the grounds in the Chicago Parks, U.S.A., concrete played a very prominent part, and these parks form a very striking example of what can be done by the use of concrete in artistic buildings, ornamental ground pieces and flower receptacles.



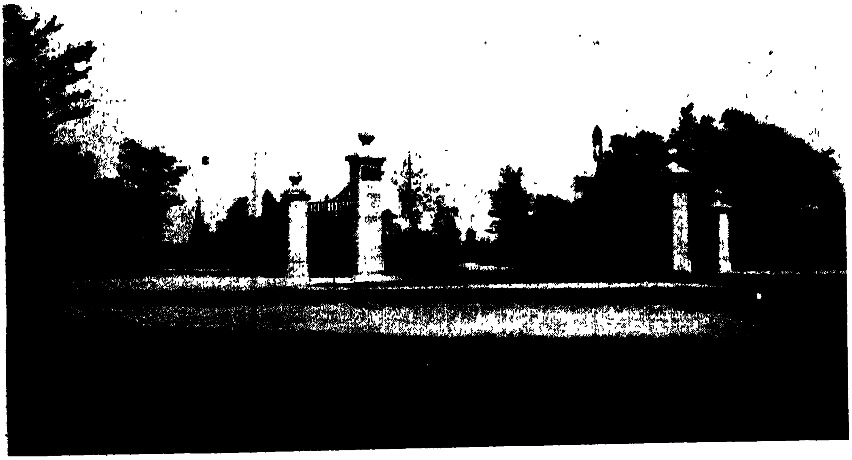
Concrete Flower Urn.
Washington Park, Chicago, U.S.A.

Sherman Park.—The entrance to this park is marked by six heavy reinforced concrete pillars or gate-posts of ornamental design. Just inside the gates is a pebble concrete arch bridge spanning a lagoon. The top of the bridge, or guard rail, is capped with concrete slabs made in sections. Two such bridges are to be found in this park.

Fuller Park.—This park has a very fine recreational building of three stories, with a fountain court and corridor or cloister of four sides in concrete. There is also a very large swimming tank and bathing house. This swimming tank is lined with white terra-cotta.

Washington Park.—Among the many interesting features in Washington Park are numerous urns, fountains, and concrete was largely used in the construction and in the

ornamentation of the administration building in this park. Our illustrations show some ornamental flower-pots and pedestals. In the construction of these pedestals a mixture of 1 part limestone screenings, 2 parts pink granite screen-

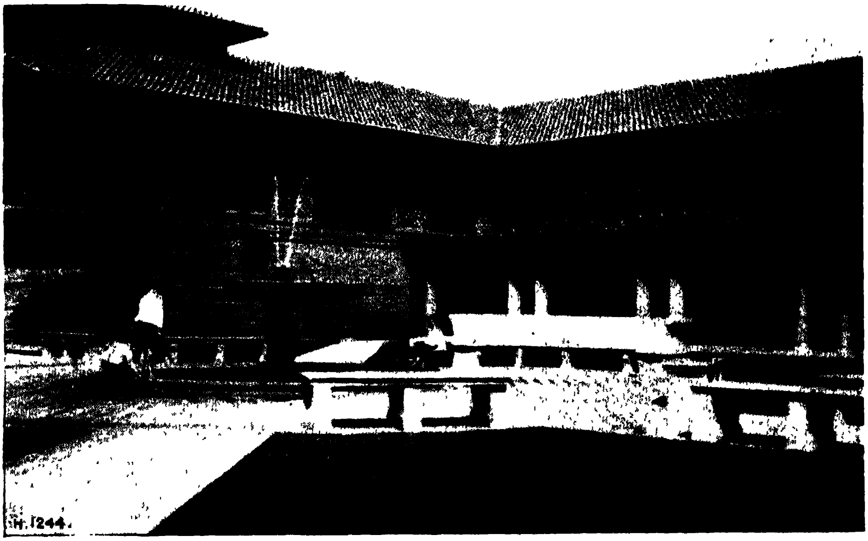


Concrete Posts.
SHERMAN PARK, CHICAGO, U.S.A.

Pebble Concrete Bridge.
SHERMAN PARK, CHICAGO, U.S.A.

ings, with 1 part cement to 2 parts of limestone and granite was used. This mixture was placed inside two sections of a gelatine mould cast from the object to be reproduced and bound firmly together by rope.

The upper basin is of the same material. No terra-cotta lining was used in constructing the bowl, but it was reinforced at the top with wire netting and ½-in. rods spaced 10 in. apart. A 1-in. finishing coat was later on applied



Inner Court, Recreational House
FULLER PARK, CHICAGO, U.S.A.

Concrete Swimming Pool.
FULLER PARK, CHICAGO, U.S.A.

composed of 2 parts sand, 1 part cement and 1½ gallons of a waterproofing compound called *Hydrolite* to each barrel of cement.

Wading pools and swimming tanks abound in these parks and are sometimes surrounded with concrete benches.

Among other remarkable features of these parks we would mention a con-

crete breakwater in Jackson Park. The entire body of the breakwater, which also acts as an inlet to a chain of inner lakes, as well as the heavy, short pillars and double bar railing, are of reinforced concrete. In this park, also,

Pebble Concrete Bridge.
SHERMAN PARK, CHICAGO, U.S A.

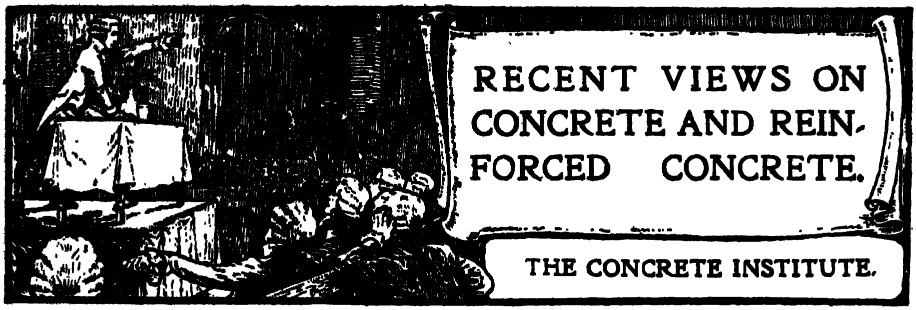
Reinforced Concrete Recreation Building.
FULLER PARK, CHICAGO, U.S.A.

there is a golf course with numerous fountains of running water cast in concrete. These fountains are 2 ft. 6 in. in height and are reinforced about the basin and pedestal and surrounded at the base by a wide platform of

concrete pavement. The interior of the basin has been finished with a coating of cement, no terra-cotta being used to line these small fountains.

The use of concrete has been found to be particularly advantageous in this park on account of the dampness about the heavy foliage where buildings are often erected. For this reason alone, the writer of the article states, the wide-spread use of the material is rapidly increasing, and as time goes on all the frame construction which rots away will be replaced by permanent concrete structures, upon which time and damp have no effect.

Concrete Flower Pots.
WASHINGTON PARK, CHICAGO, U.S.A.



It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

ACTION OF ACIDS, OILS AND FATS UPON CONCRETE.

By W. LAURENCE GADD, F.I.C., M.C.I.

The following is an abstract of a paper read at a meeting of the Concrete Institute on December 12th, 1912. In connection with the paper the author gave numerous tables setting out the tests made by him, but we only reproduce tables A, B, and F here. A discussion followed, of which a summary is also given.

GENERALLY.

NEITHER cement nor concrete will withstand the action of hydrochloric, nitric, and sulphuric acids. They decompose and dissolve the constituents of cement, even in dilute solution. Even a weak acid, like carbonic acid, has a distinct action upon cement, which, suspended in water, can be practically entirely carbonated by passing a current of carbon dioxide into it.

The action of organic acids, such as lactic and butyric acids, tannic acid, tartaric and citric acids, and acetic acid or stale beer, is not so marked; but it is very probable that the whole of the series of higher fatty acids will be detrimental to concrete.

The tendency of organic acids to combine with carbonate of lime is much less than with hydrate of lime, and it follows that an acid which would be dangerous in contact with green concrete might be perfectly harmless in contact with old or indurated concrete. Thus, stale beer has a distinctly detrimental action upon new work, but once the concrete has indurated by exposure to air for some time, the acid of sour beer has little action upon it.

Fresh beer has, itself, a weakening action on green concrete; but the deterioration in this case is due to the sugar and other organic constituents of the beer, and not to the action of beer acids.

TABLE A.

Tensile Strength (lbs. per square inch.)

	NEAT.			SAND (3 : 1).	
	3 Days.	7 Days.	28 Days.	7 Days.	28 Days
Kept in water	630	765	1,020	340	425
	620	730	960		
	625	747	990		
	Plunge pat—Sound.				
Kept in beer	620	710	810	300	360
	560	675	750		
	590	692	780		
	Plunge pat—Failed.				

The test pieces were gauged with water in the usual way, and after twenty-four hours in moist air were immersed in water and beer respectively until due for breaking.

One of the commonest forms of acid action to which building material is subjected is that of sulphuric acid, derived by oxidation from the sulphurous gases present in the atmosphere of large towns. This is noticeable on Portland stone, but appears to be less marked on concrete buildings, possibly for the reason that the surface pores of concrete become closed with a deposit of calcium sulphate, which affords protection from further action of the acid.

Lactic acid is produced by the fermentation of milk, brought about by the micro-organism *Bacterium lactis*, and is a possible acid to come in contact with concrete structures in farm buildings. The action of this acid is confined to combination with calcium hydrate, forming calcium lactate (Ca $(C_3H_5O_3)_2 + 5H_2O$). This salt is soluble in water, and in wet situations would be readily leached out of concrete in which it was formed, so that the deleterious effect of lactic acid would consist in the gradual removal of the lime hydrate, which plays an important part in the induration of concrete. For practical purposes, it is probable that this action would be very small.

The following tests show the effect of prolonged immersion in a solution of lactic acid, prepared by fermenting milk, and removing the curd :—

TABLE B.

Mortar 4 : 1 (ordinary building sand).

Test pieces 1 day in air, 27 days and 3 months in the whey and in water respectively.

	Tensile Strength.		Crushing Strength.	
	28 Days.	3 Months.	28 Days.	3 Months.
In whey	430	470	4,700	6,700
	440	470	4,900	6,000
	435	470	4,800	6,350
In water	400	495	4,600	6,800
	410	480	4,750	7,000
	405	487	4,675	6,900

This is, of course, a much more drastic test than would be at all likely to occur in practice, but the results do not disclose any marked deterioration caused by the lactic acid.

Concrete vats would appear to be suitable for tanning operations, and the possible action of tannic acid becomes of importance. This acid, of which gallotannic acid ($C_{14}H_{10}O_9$) may be taken as a type, is again an organic acid which combines with calcium hydrate to form calcium tannate, but as the combining weight of tannic acid is high—sixteen parts by weight combining with only one part of calcium—the probable action is not very serious.

Various tests have been carried out in order to ascertain the effect of gauging with a solution of tannic acid (two grammes per litre), and, for comparison, test pieces of the same cement were also made in the usual way, gauging with water only.

It was found that the test pieces gauged with tannic acid solution gave lower tensile and crushing strains, but the difference is not sufficient to mark any great deterioration.

OILS AND FATS.

Proposals have of late been made, particularly on the other side of the Atlantic, to incorporate a certain small amount of oil or fat with concrete, with the object of giving the same dustless, waterproof, and other qualities. What we might almost call the natural instinct of the concrete worker has, however, always led him to avoid oil or grease as far as possible, and he has been right.

Many oils and fats react chemically with the cement constituents, and in this class must be placed the whole of the oils and fats of animal or vegetable origin.

These substances consist of the glycerides of various fatty acids, such as stearic, palmitic, and oleic acids.

The glycerides of the fatty acids, which constitute the neutral oils and fats of animal or vegetable origin, are readily decomposed, or saponified, by certain metals

and metallic salts, and by all alkalies, including calcium hydrate, which we know is a constant product in cement or concrete which has been gauged with water. The result of this saponification is the decomposition of the oil with the formation of a metallic or alkaline salt or soap, and the liberation of glycerin.

Thus, tallow is saponified by calcium hydrate, according to the following equation :—

$$2C_3H_5(C_{18}H_{35}O_2)_3+3Ca(OH)_2=2C_3H_5(OH)_3+3Ca(C_{18}H_{35}O_2)_2$$

Tristearin (tallow)+calcium hydrate=glycerin+calcium stearate (lime soap).

Calcium stearate is a whitish, friable material, insoluble in and immiscible with water; whilst the lime soaps of other fatty acids commonly occurring in oils and fats are slimy and sticky substances which, although water repellents, do not, so far as the author's experiments show, render concrete less permeable to water, and decidedly reduce the tensile and crushing strength.

By this process of saponification, which takes place rapidly under the influence of heat and more slowly in the cold, cement or concrete will certainly be injured by the admixture of any animal or vegetable oil or fat; and if the concrete be green or new, there is some liability of damage being done to it by mere contact, such as might occur from constant drippings of oil upon it.

Calcium carbonate has not the power to saponify neutral oils or fats, so that oil in contact with indurated concrete, in which the calcium hydrate has been largely converted into carbonate, would have little deleterious action.

Mineral oils and greases, which are hydrocarbons, are of a different constitution from that of the animal and vegetable oils, and are incapable of saponification. They have, therefore, no injurious action from this particular cause, although they weaken the strength of concrete for physical or mechanical reasons.

This is experimentally confirmed by a series of tests on sand mortar 3 : 1, in which various oils and fats were incorporated to the extent of one-tenth of the weight of cement used.

The oils and fats used were vaseline, cylinder oil, lard, cotton seed oil, and colza oil.

The tests were for periods of seven days, one, three, six and twelve months.

The results of the tests showed that the vegetable and saponifiable oils, cotton seed and colza, are absolutely destructive to concrete, and that the mineral oils, which are not saponifiable, reduce the strength very materially when mixed in small proportion with the mortar.

When testing samples of cement for tensile strength, the author observed that many operators use colza oil for the purpose of greasing the briquette moulds. The film of oil which remains, or should remain, on the moulds is, of course, very thin, but colza oil cannot be considered a suitable oil for the purpose, seeing that it has so great an action upon cement. Briquette moulds should be oiled with mineral oil, or a mixture of heavy mineral oil and paraffin.

In order to test the waterproofing qualities of oil-mixed concrete, flat slabs of similar mixtures to the above were made in a standard manner, and, after twenty-eight days, were submitted to percolation tests by subjecting them to a water pressure of 50 lb. per sq. in., in such manner that the water forced through the slabs could be collected and measured. The following table sets forth the results obtained :—

TABLE F.

Slabs kept 28 days in water before testing. Size of slabs—10 x 10 x 3 in.

Area subjected to water pressure—16 sq. in.

WATER PERCOLATED THROUGH THE SLABS.

Oil added.		Litres per Hour.
None (cement only)	(1)	4·7
	(2)	17·7
Vaseline	(1)	1340·0
	(2)	340·0
Cylinder oil	(1)	695·0
	(2)	260·0
Lard	(1)	Slab broke
	(2)	,,
Cotton-seed oil	(1)	,,
	(2)	41·2
Colza oil	(1)	Slab broke
	(2)	,,

It is to be noted that these slabs were not intended to be made absolutely watertight, the object being to obtain a comparison. Leighton Buzzard sand was therefore used, and the results show that under identical conditions sand mortar without any addition of oil was more watertight than with any of the oils or fats tried. The addition of lard, colza, and cotton-seed oils to the extent of less than 2·5 per cent. on the weight of the concrete prevented the slabs from setting properly even after twenty-eight days, and they were unable to withstand the water pressure placed upon them.

In order to test the effect of oils upon concrete gauged with water in the usual way a number of briquettes were prepared, consisting of four parts of ordinary building sand to one part of cement; and after twenty-four hours in moist air these were immersed in various oils for periods of one, three, six and twelve months, at which dates the tensile and crushing strengths were ascertained.

A further series of similar test pieces was prepared, but in this case the briquettes and cubes were allowed to mature in air for twenty-eight days before they were immersed in the oils.

These tests again bring out the destructive action of saponifiable vegetable oil, the test pieces immersed in cotton-seed oil being reduced to mud in less than three months; and although the mineral oils and turpentine had much less marked effects, they nevertheless materially reduced the strength of the concrete immersed in them.

The broken briquettes, which had been immersed in oils for twelve months, were freed from the sand, as far as possible, by sifting, and from adhering oil by repeated extractions with ether, and then submitted to chemical analysis.

There were five samples, A, B, C, D, E. The first four had been one month in air and twelve months in oil. Sample E was only one day in air before immersion in oil.

The results showed that concrete in contact with certain oils suffers chemical change by the combination of the liberated calcium hydrate with the fatty acids of the oil, as much as 32 per cent. of oil being combined in a period of twelve months, when green concrete is immersed in cotton-seed oil.

This amount of oil in combination as calcium oleate and stearate is quite sufficient to account for the disintegration of the concrete.

In parallel cases of briquettes immersed in cotton-seed oil after one month's irduration, and after one day only in air respectively, the action of the oil was much less marked in the former than in the latter, due to the fact, as mentioned earlier in this paper, that fattv acids do not react with calcium carbonate.

CONCLUSIONS.

The conclusions drawn by the author from theoretical and experimental data are :—

1. That the addition of oil or fat, of any kind, to concrete results in a weakening of the strength.

2. That animal and vegetable oils have a direct action on green concrete, and in time will bring about its destruction.

3. That indurated concrete is less liable to be attacked by oils and fats.

4. That oil-mixed concrete is not rendered more waterproof. The least permeable concrete is, in the author's opinion, a dense mortar in which the aggregate is properly graded to fill the voids.

DISCUSSION.

The President: One thing Mr. Gadd has proved is this, that the addition of any extraneous matter to Portland cement does not improve its strength. It is well known that where acids come into contact with concrete, then destruction is bound to take place sooner or later. In amplification of this paper Mr. Wells stated he had made some experiments six or seven years ago as to the action of creosote upon concrete. He was designing a tank to contain creosote, and wanted to find out what the action of creosote would be upon concrete which had been kept under air for six months, three months; five to one concrete, three to one sand, tests and neats; and in every instance where it has been kept in creosote for 18 months the strength was higher than when it was kept in water. In the case of neat cement, after 18 months the test for crushing amounted to 1,163 tons a sq. ft., and 9·46 tons a sq. in. It had been kept under normal conditions—that is to say, anywhere ranging from 40 to 60 degrees Fahrenheit—and during the whole of the period in the neat cement tests the creosote had not permeated it

at all, and it had only entered to about one-eighth of an inch, except where one sample was made with a very soft and porous stone, where it went right through. But where the same tubs were then placed in a chamber where the creosote was heated to 120 degrees in less than 14 days it went clean through the neat cement.

Mr. D. B. Butler, Assoc.M.Inst.C.E., F.C.S. (Member of Council C.I.): Only those who have had occasion to undertake research of this kind can realise the immense amount of work involved in a paper as the one prepared by Mr. Gadd.

It is a little peculiar that the very first substance or liquid mentioned in the Paper is beer. As a rule the effect of beer on concrete is very indirect. But he would like to ask, referring to the beer tests, as to what effect the beer had on the setting of the cement. Mr. Gadd in most of his experiments only gives the average of two cubes or briquettes on each date, and in referring to Table B it will be seen there that the result at three months in whey, if only one briquette should have been taken instead of two, the result in the one instance would have been 6,700, and in the water 6,800, practically the same; so it shows really the necessity in all these experiments for taking a fair average; two is hardly enough.

With regard to the tests where the cement was gauged with tannic acid, comparative tests are given with tannic acid and water. In this experiment the test pieces in each case were mixed with a solution of tannic acid. That seems to be scarcely as practical as it would have been if the test pieces had been made with water in the ordinary way and immersed in a solution of tannic acid. Briquettes of concrete are not as a rule gauged with tannic acid, but sometimes, as shown, it is subjected to the liquids from tanning.

He quite agreed with Mr. Gadd's remark where he refers to what he calls the natural instinct of concrete workers in avoiding oil or grease in any way. We know that in moulding briquettes and moulding test pieces we oil our moulds. Do we oil our moulds to make the cement stick to the moulds or otherwise? So it seems a very fair answer to mixing oil of any kind with cement.

Regarding the results of the test of the various vaselines and oils mixed with cement, it would be interesting to know how the author managed to mix vaseline and oil with the concrete in those small proportions and the method in which he did that.

Referring to the colza oil tests, it is a little curious that the seven days' results show a small crushing strength; the one month and three months' show no strength at all; then they go on again, and in six months' and twelve months' they have gained some strength again.

Regarding the percolation tests, some further particulars are needed. Some twenty-five years ago Mr. Faija in his forced percolaton of sea-water through concrete, used half-inch briquettes, composed of three to one sand, a brass clamp was fixed top and bottom of the briquette, to which was attached a screw nozzle to the pipe, and then same was attached to a water tank 15 ft. above, so that a 15 ft. head of water was obtained forcing through this briquette, and after a time it was found the percolation ceased entirely owing to the blocking up of the pores both with sea water and fresh water.

Regarding the test pieces immersed in various oils compared with water. It is certainly rather drastic to immerse a briquette into absolute oil and turpentine. But it is curious that the tensile strength of the cotton-seed oil is absolutely *nil* in each case, whereas the crushing strength varies from 900 lb. to 1,700 lb. at various dates.

The same irregularity occurs in the tests where the cotton-seed oil at one month gives only an average of 62 lb. tensile, but an average of 2,675 crushing. As a rule, the ratio between tensile and crushing is somewhere about ten to one—that is, the crushing is about ten times the tensile, and, curiously, in this case it is roughly only about a one-hundredth part.

Regarding Table F, it would be interesting to know if in addition to the analyses of the briquettes immersed in the various kinds of oil, showing the combined oil and combined water with extracts of the oils and sand, whether a briquette had also been analysed which had been immersed in water only showing the amount of combined water in the briquette.

With reference to sample E, which was only kept in air one day before immersion for twelve months, whereas the other samples had been kept in air for one month, this seems a little peculiar, and it would be interesting to know why this was done.

Mr. A. Alban H. Scott, M.S.A. (Member of Council C.I.): There is rather a curious coincidence in the tests with oils and fats. The crushing strength of the cement at seven days is about 4,000, and at twelve months it is almost all the way through just double that strength.

With regard to the percolation of water through the cement, a very large reinforced concrete structure had been put up about eighteen months ago, and it had very slight leakages at first, but all those pores are filled up, and he believed that is the usual experience with concrete subjected to a head of water, that it does, if properly made, become eventually more or less watertight, assuming, of course, it is fair average concrete for that class of work.

But an interesting thing which the client did in that case was this: he threw oatmeal into the water, and whether it was the oatmeal that gradually, with the very slight movement of water, actually filled up the points of leakage, or whether it was due to the action of the cement is questionable.

Mr. R. W. Vawdrey, B.A., Assoc.M.Inst.C.E. (Member of Council C.I.), asked the author to what extent he thought that the weakening of the concrete, either tension or compression, was due to the actual diminution of the size of the concrete. In some cases, at any rate, he assumed, where the action was very marked, as in the case of colza oil, on some of his briquettes, there was an actual diminution in the size of the block. Apart from that, however, there must be a considerable proportion of the interior of the block or briquette that is quite unaffected. It would be rather interesting to know what area of the cube or briquette was actually affected by the oil. In some cases it need not be necessarily affected throughout its depth.

Mr. Percival M. Fraser, A.R.I.B.A., M.C.I., in asking whether any volatile oils had been under discussion in the paper, stated that petrol in reinforced concrete is so much to the fore in these days that a little experiment in connection with the two might be quite interesting.

Mr. Frederick Hingston (M. Quantity Surveyors' Association) thought Mr. Gadd's paper most opportune, because at the present time there are in the market a number of patent preparations or compositions which if added to cement are supposed to make it waterproof. These patent preparations doubtless include fatty acids. It would be of value to know whether the lecturer considers the addition of those materials, that can be seen upon the pages of all the professional journals, is detrimental to cement and concrete.

Mr. G. C. Workman, in his opening remarks, inquired whether there is any danger in mixing soap with the concrete, assuming that it has the beneficial effect of making it water-tight, as recently shown in the American Press.

Referring to the whole trend of this paper, he was very pleased to see that it absolutely confirms what he has always held to be a rule for concrete engineers to work upon when dealing with any of these greases or acids—namely, that it seems, by various tests which have been made that mineral oils and greases which are hydro-carbons do not seem to affect the concrete, but animal and vegetable oils seem to affect it. He had always held it as a very broad rule that in dealing with concrete which has to contain any animal or vegetable oil, it is dangerous, if the concrete is to resist the effects of mineral oils cold—he had no knowledge about them hot. All the information he had been able to gather from tests and reports from various sources on the subject, and all he had read, seemed to be borne out by Mr. Gadd's experiments, which are certainly of great value, and which, no doubt, will be very useful to reinforced concrete specialists in particular, seeing that they are continually coming into contact now with the question of reservoirs and pipes which have to contain fats and acids; and, especially with regard to naphtha and various other mineral oils, he was inclined to think there was no danger in making the reinforced concrete reservoirs and pipes to restore this material, if cold. In spite of all the evidence on the subject, it is very strange to have to say that there seems still to be a certain amount of doubt. He had seen small reservoirs filled with crude oil, mineral oil, and had been told that that oil had been standing for three months without any detrimental effect to the reservoirs. M. Coignet, as a matter of fact, at his instigation, has filled pipes to a certain height with mineral oil in order to find if they leaked. After several months it was found that the oil is there, and they do not seem to have leaked. From information from Baku and various other sources where they seem to be using large reservoirs for the storage of naphtha, they seemed all right; but still, if he were asked to take the responsibility of it, he did not think he would dare to do it, because there still seems to be a certain amount of doubt.

Mr. Vawdrey asked at what age concrete was sufficiently indurated to resist the action of mineral oil. It appears it does not set after a certain age; at what age did the author consider the dangerous period is passed?

The President, with reference to the question of waterproofing compounds, had found in all cases after three months the crushing strength is gradually reduced. He had only gone on now for a period of three years; but it is going down all the time. He was making some further experiments with waterproofing compounds guaranteed to increase the strength. But there is no doubt about it they may temporarily do good and stop leakage, but in time they weaken the concrete so seriously that damage is likely to take place.

MR. LAURENCE GADD'S REPLY.

Mr. Gadd: Mr. Butler says many of the test results are anomalies, and he drew attention to the fact that in all cases an average of not more than three is given. This was due to the fact that not sufficient time had been available for a larger number of test pieces.

It was not claimed for the paper that it was an exhaustive treatment of the subject; but, looking at it generally, even the two or three briquettes can be accepted as some indication—if not by any means final—of a line of investigation which it is hoped will be carried out by other members of the Institute..

As to the immersion in tannic acid, it might certainly have been better to have immersed water-gauged briquettes in tannic acid. But, as a matter of fact, the particular tests described in the paper were not made for the purposes of this paper, but were made with another object altogether. It would have been impossible during the time available for the preparation of this paper to have given tests of more than a month or two's duration, so that some tests were used which had been made about eighteen months ago for a totally different purpose.

Mr. Butler's point about greasing moulds is an excellent one. He also raised one or two other questions. He wanted to know how the oil and grease were mixed with the cement or with the concrete. The amount of oil was very small; it was one-tenth of the weight of the actual dry cement, and was mixed with the dry cement in the first instance. With the harder fats, like lard, the lard was slightly warm and the whole was mixed in the mortar with the dry cement; it was rubbed into the cement before gauging at all. Then the sand was added and the whole mixed up, and finally it was gauged in water in the usual way.

As to the method of making percolation tests, slabs of concrete 3 in. thick and 10 in. square are taken, and these slabs are put between rubber washers (indiarubber an inch thick), and they are squeezed down between two steel plates, those steel plates forming the flange of a cup, more or less, in shape. The steel plate joins on to the rubber. There is one indiarubber washer, then the slab and one indiarubber washer below, and the whole is screwed down so as to make it tight at the joints. At the top of this cup there is an inlet through which the water is forced. The water pressure is got by means of a pump and an accumulator, so as to keep constant pressure on the slab. The other cup is simply perforated at the bottom where the water is collected.

Regarding Mr. Alban Scott's remarks about percolation of concrete, his experience had shown that after a time even concrete which was porous closed up. As the concrete goes on indurating, setting, hydrating, the pores gradually close up, and there is no better way of making a concrete waterproof than to force water through it for an hour or two under very high pressure. If it is then allowed to dry it becomes almost absolutely waterproof.

Regarding Mr. Vawdrey's remarks as to what extent a diminution in the size of the block was observed, it was found that the edges were worn; there were no sharp edges; even those briquettes which stood a certain amount of strain on the outside were indeterminate in shape.

Regarding the term "saponification," it comes from the fact of the decomposition of a neutral oil. In speaking of a neutral oil, it is to be quite understood that the ordinary oils as we know them are not fatty acids; they are compounds of the fatty acids, just in the same way as salt is a compound of hydrochloric acid. Tallow in combination with calcium hydrate largely consists of a dry stearine; it is a compound in which a portion of the hydrogen of the fatty acid is replaced by glycerine radical, and the process of saponification is merely to dissociate the glycerine radical again from the fatty acid. The glycerine is set free, or rather the glycerine radical which combines with the element of water; glycerine as we know it and the fatty acid which was formerly in combination with the glycerine radical goes into combination with the lime, with the calcium. The reason it is called saponification is because in these cases the metallic salts which are formed from these fatty acids are all soaps, hence the term "saponification," or the production of a soap.

As to Mr. Workman's remarks about the waterproofing compounds which are being pushed pretty well on the market just now, the lecturer said he was not interested in waterproof compounds either one way or the other, but for his own information he had examined, analysed, and tested in relation to their effect upon tensile and crushing strength, and on waterproofing in particular, practically all the waterproofing compounds that are on the market. He would go so far as to say that they are practically all the same.

The bulk of these compounds consists of hydrate of lime with about 10 per cent. of lime soap. The reason of this is it is supposed to be calcium stearate, but owing to the crude way in which the calcium stearate is made they only get about 10 per cent. of calcium stearate, and the rest is simply lime. It may be agreed that they may have some action in stopping up pores, so far as the free lime is concerned—that is to say, the lime hydrate—but, as a matter of fact, the calcium stearate part of it is a detriment rather than an assistance. The lecturer had not found a single one of these compounds which renders concrete more waterproof than plain concrete, but rather the reverse.

NEW WORKS IN CONCRETE

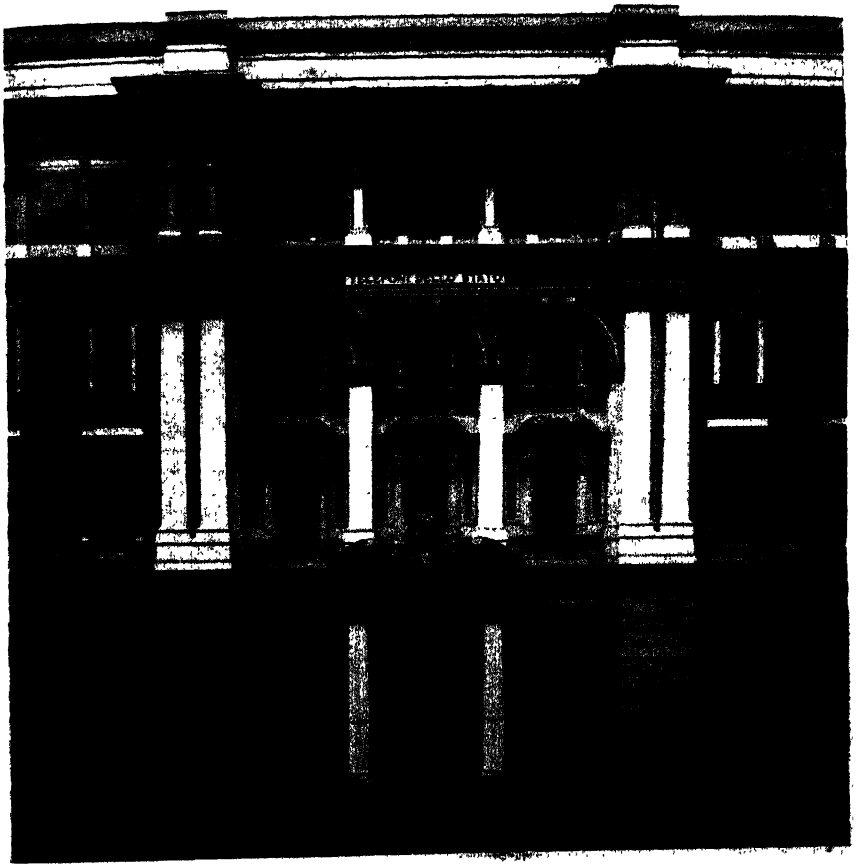
AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

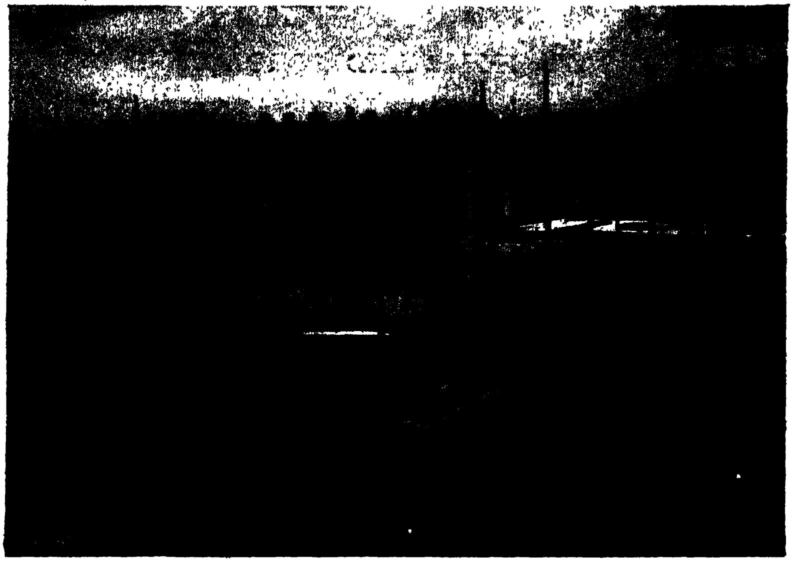
THE NEW GENERAL POST OFFICE IN MILAN.

ALTHOUGH only opened seven years ago, the General Post Office of Milan has been found quite inadequate for its purpose, especially since the taking over of the telephone service, and a new building has been constructed recently for the three departments of Posts, Telegraphs, and Telephones. This building incorporates a part of the former Post Office, and also covers the site of two churches and a number of offices and houses.

The walls and the vertical skeleton of the new building, with the exception of the ground floor columns, are constructed in brickwork set in hydraulic lime, whilst the

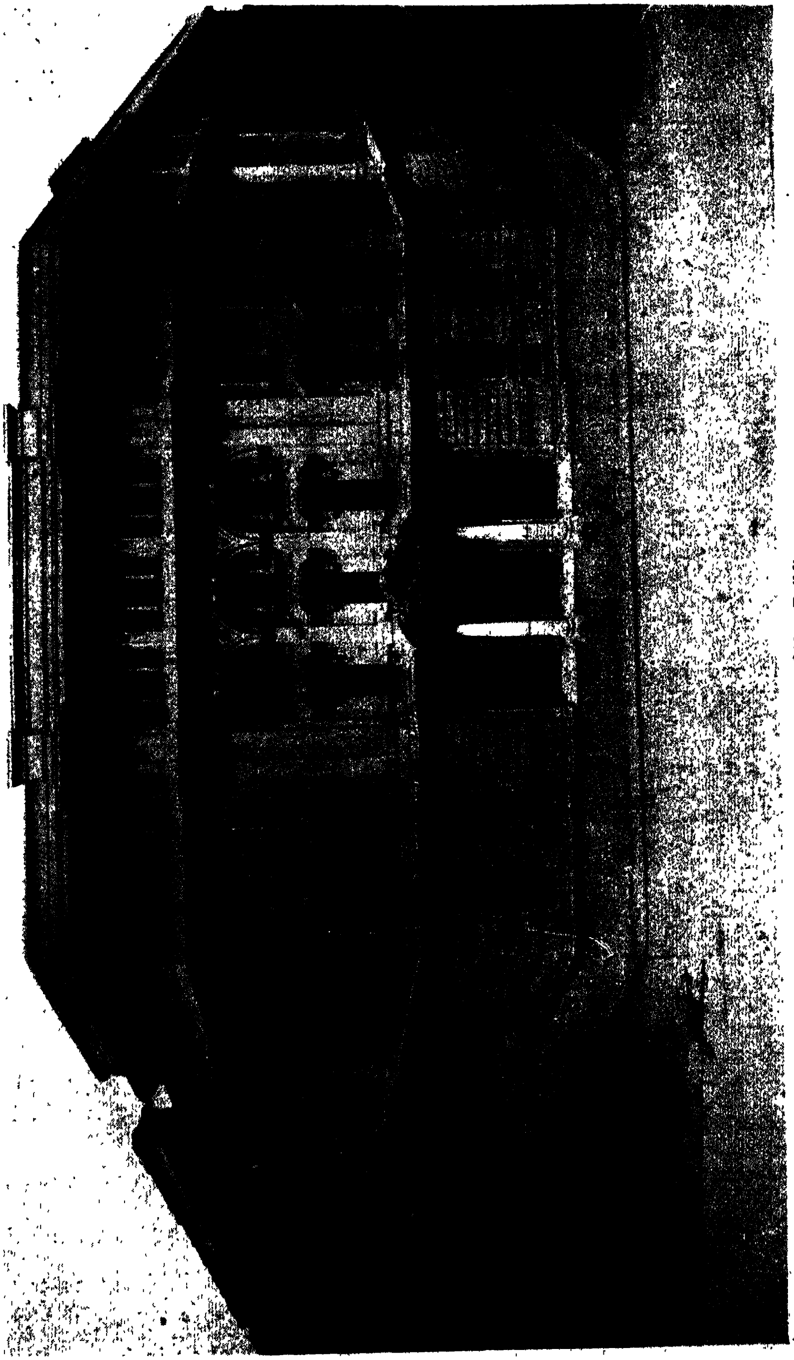


Entrance to Telephone Offices.
THE NEW GENERAL POST OFFICE, MILAN, ITALY.



Process of Concreting a Floor.
THE NEW GENERAL POST OFFICE, MILAN, ITALY.

Underside of Roof, Urban Telephone Exchange during removal of centering.
THE NEW GENERAL POST OFFICE, MILAN, ITALY.



Main Entrance of New Building.

THE NEW GENERAL POST OFFICE, MILAN, ITALY.

floors, beams, terraces, etc., and the ground floor columns, are of reinforced concrete. The most important part of the building in this respect is the urban telephone exchange, a large hall 105 mètres long and 14 mètres broad. The roof of this hall is a hollow floor, carried on arched beams, above which are the pilasters and architraves of the attic floor, also in reinforced concrete. The construction of this roof is seen in *Fig.* 3. In order to relieve the outer walls of thrust, two longitudinal girders of reinforced concrete are used to take the thrust, these again transmitting a purely vertical load to the walls.

The work was carried out rapidly, as much as 60 cubic mètres of concrete being put in place on a favourable day. Loading tests were carried out on each floor with one and a half times the prescribed load, the deflections observed amounting to only $\frac{1}{5000}$ of the span, without permanent deformation. The reinforcement is mainly on the Volpi system. The contractors were Galimberti Bros., and the constructional engineer Sr. G. Ferrini.

Our illustrations show (1) the entrance to the telephone offices; (2) the process of concreting a floor; (3) the underside of the roof of the urban telephone exchange during the removal of the centering; and (4) the main entrance of the new building.

In conclusion we would add that we obtained our particulars from an article in the Italian journal *Il Monitore Tecnico* written by the engineer, Mons. Giovanni Pizzamiglio, of Milan, and we are indebted to the latter for our illustrations.

BALLINGDON BRIDGE, SUFFOLK.

THE existing timber bridge over the River Stour between Ballingdon and Sudbury has recently been demolished and a new bridge constructed in reinforced concrete on the Hennebique system, to give the increased accommodation necessary for carrying the growing traffic of the district.

The new bridge is about 112 ft. span between the concrete abutments which have been reconstructed, and is supported on four rows of four reinforced piles abreast, making three spans of about 37 ft., the centre span being slightly larger than the end spans. The reinforced concrete piles are 16 in. by 16 in. in cross-section, the longest being 29 ft. and the shortest 17 ft. overall, and they were driven without any difficulty.

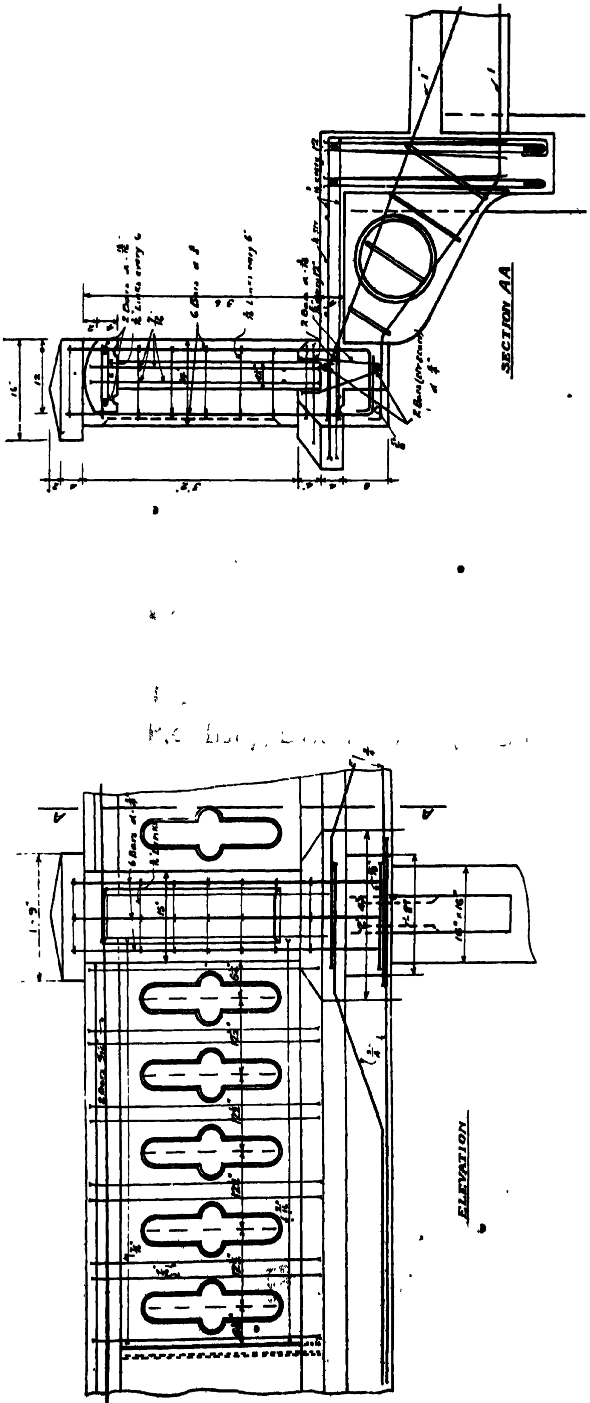
The width of the new bridge between the curbs of the roadway is 26 ft. with a 5 ft. footpath on either side, making a total width between parapets of 36 ft., the footpath being carried by cantilever brackets at intervals on the external main beams. The main beams of the bridge are all 10 in. wide, those in the centre bay being 1 ft. 9 in. below the decking level and in the end bays 1 ft. 6 in., the reinforcement in the inner beams of the end bays consisting of six main tension bars $1\frac{13}{16}$ in. diameter and two bars $1\frac{1}{4}$ in. diameter in compression, the shear members being $1\frac{1}{4}$ in. by $\frac{1}{8}$ in. hoop steel throughout; the outer main beams are arranged to project up to pick up the footpaths, making a total overall depth of 3 ft. 3 in. Caps are provided to each of the pile heads just above normal water level, and the horizontal bracings, 15 in. by 8 in., come immediately above them. The decking is $5\frac{1}{2}$ in. thick throughout, the main reinforcement consisting of $\frac{1}{2}$-in. diameter bars straight and curved alternately at 6-in. centres at the bottom, with $\frac{1}{4}$-in. diameter bars straight at the top spaced every 9 in. The secondary beams are 12 in. deep, 6 in. wide, and are at 5-ft. centres, the reinforcement consisting of two bars 1 in. diameter with shear members out of $1\frac{1}{4}$-in. by $\frac{1}{16}$-in. hoop steel.

The parapet, which is in reinforced concrete throughout $4\frac{1}{2}$ in. thick, is similar to that of Rod Bridge recently constructed in the district, and was cast in 5-ft. lengths and afterwards fixed *in situ*, the coping being moulded on same afterwards.

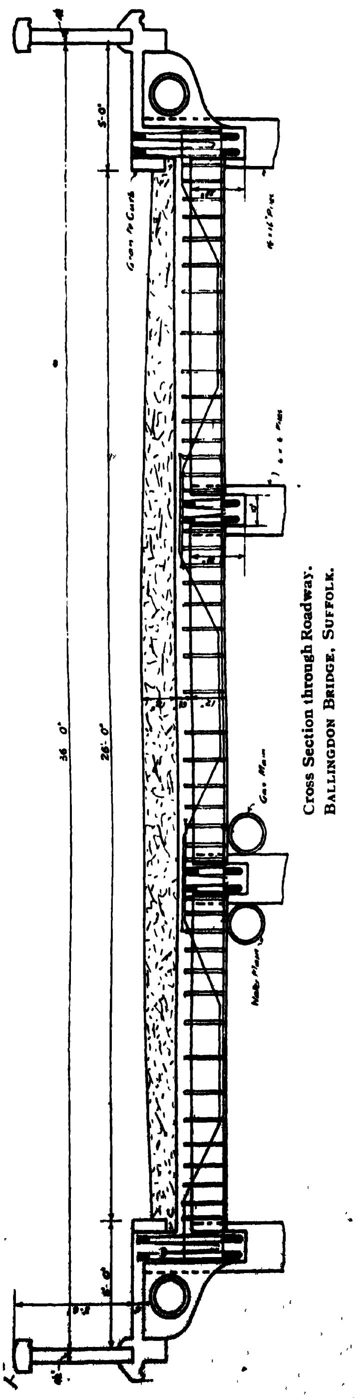
In order to keep the road open to light traffic, it should be mentioned that the bridge was constructed in two halves, a portion of the old bridge being left up until one-half of the new structure was opened, when the old portion of the bridge was demolished and the new bridge completed, the roadway being finished off with "Tarmac" on hardcore and the footpaths in granolithic.

The work was commenced in April last and the new bridge was tested on December 5th with very satisfactory results, the maximum deflection observable under the full test load of three steam-rollers, each weighing 16 tons and travelling two abreast and one following, being slightly over one-sixteenth of an inch.

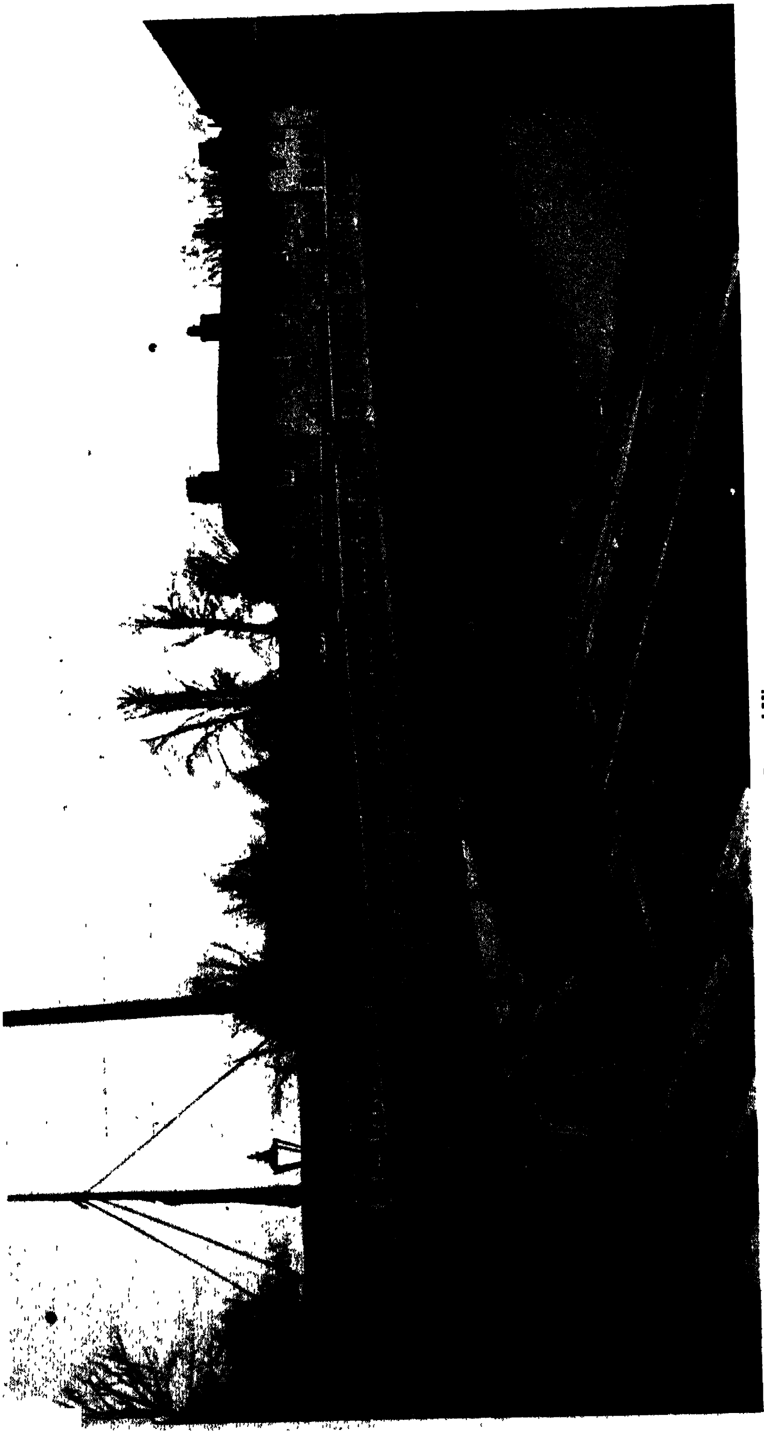
The architect for the work was Mr. Ainsworth Hunt, the County Surveyor for Suffolk. The consulting engineers were Messrs. L. G. Mouchel and Partners, Ltd.,



Typical Detail of Parapet.



Cross Section through Roadway.
BALLINGDON BRIDGE, SUFFOLK.

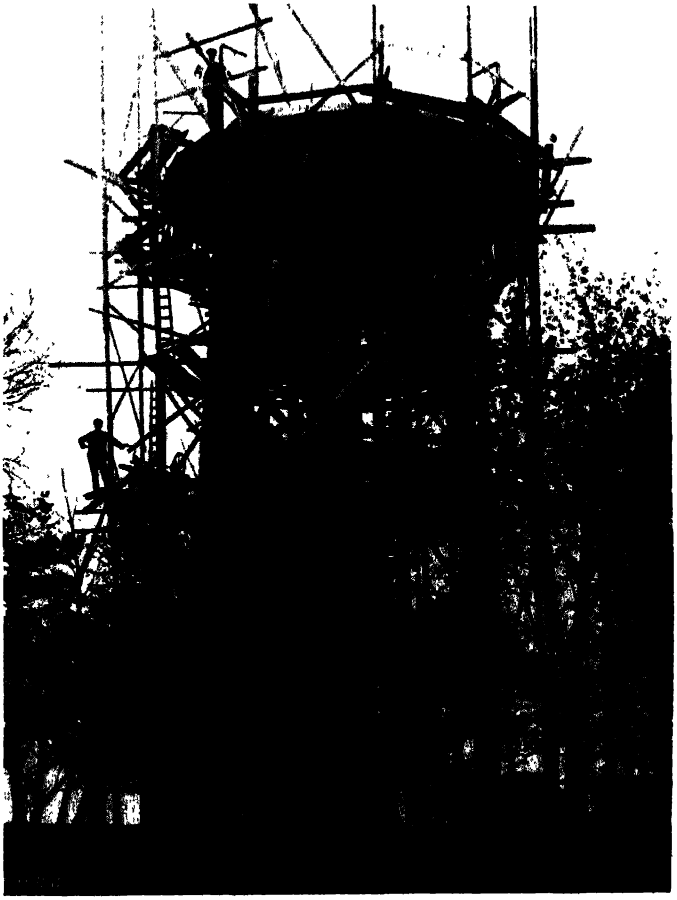


General View.
BALLINGDON BRIDGE, SUFFOLK.

of 38, Victoria Street, Westminster, S.W., who prepared the reinforced concrete detail drawings, and the contractors were Messrs. Holloway Brothers (London), Ltd., of 19-21 Belvedere Road, Lambeth, S.E.

REINFORCED CONCRETE WATER TOWER AT SCOPWICK.

THE Sleaford Rural District Council have again added to the large number of village water supplies, which they have provided during the past fifteen years, within the large area comprising their district.



In course of construction.

REINFORCED CONCRETE WATER TOWER, SCOPWICK, LINCOLNSHIRE.

A scheme for supplying the parishes of Scopwick and Kirkby Green, with probable extensions to the pretty village of Blankney and Blankney Hall, one of the country seats of Lord Londesborough, who has contributed one-half of the total cost of the works under notice, comprises a deep bore into the Lincolnshire Oolite, pumping-station and pipe tracks.

With the exception of the wrought-iron access ladders, the water-tower is constructed entirely in reinforced concrete on the Hennebique system, even including the pole projecting some 14 ft. above the top of the cupola.

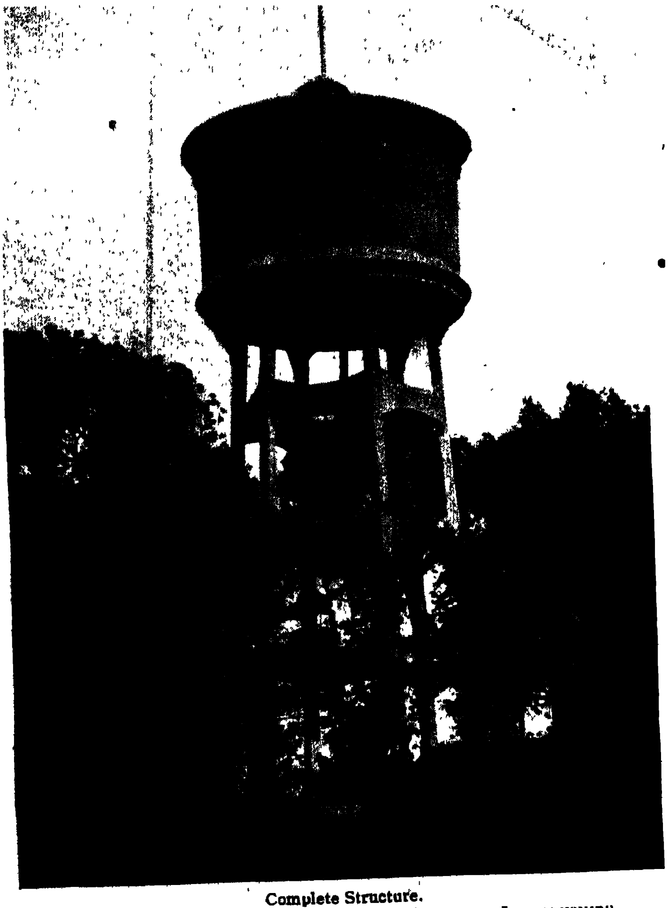
The elevated reservoir consists of a cylindrical chamber, 24 ft. in diameter inside by 11 ft. 3 in. high from floor level to the underside of roof, and has a capacity of 27,000 gallons. The outer shell of the reservoir is 5 in. thick, the bottom being of the

same thickness. The roof is 4 in. thick, and is provided with an ornamental cornice about 2 ft. high, forming a parapet.

At the centre of the reservoir is a reinforced concrete tube of 2 ft. 6 in. diameter inside, affording accommodation for the ladder furnishing means of access to the roof, the top of the opening being covered by a cupola 8 ft. high.

The reservoir is supported at the height of 50 ft. above ground level by a tower of hexagonal form, consisting of six inclined columns braced laterally at five levels.

The footings of the columns are bedded on limestone rock occurring near the



Complete Structure.

REINFORCED CONCRETE WATER TOWER, SCOPWICK, LINCOLNSHIRE.

surface, and at the ground level they are connected by a moulded plinth. The intermediate bracings are utilised for the support of the ladders and the landings in connection therewith.

At the upper end the columns are connected with the bottom framework of the reservoir, and are additionally braced by a series of arches. Cantilever brackets projecting from the columns provide for the support of the outer part of the cylindrical reservoir.

The reinforced concrete work is monolithic throughout. It is one of the very few reinforced concrete water-towers erected under a loan granted by the Local Government Board.

The interior face of the reservoir is rendered ¾ in. thick in two coats of cement

and Medusa waterproofing compound, and when under test the construction was found to be perfectly watertight. On the pole fixed at the top of the cupola is a spherical balance weight, which will act as a water-level indicator, being attached to a copper float inside the reservoir, thus showing to the engineer at the pumping station—situate 1,200 yds. lower down the valley of the Scopwick Beck—the depth of the water in tank.

The whole of the work was carried out under the personal supervision of Mr. W. B. Marsden, the engineer and surveyor to the Sleaford Rural District Council.

The reinforcing steel was supplied by the Whitehead Iron and Steel Co., Ltd., of Tredegar; the aggregate for the concrete by the Groby Granite Co., Ltd. The pumping station and pipe tracks were constructed by Messrs. W. Pattinson, Contractors, Ruskington and London; the machinery for the station was supplied by Messrs. R. Hornsby and Sons, Ltd., Grantham; and the water-tower was constructed by the Liverpool Ferro-Concrete Contracting Co., of Liverpool.

ST. MARY'S PRESBYTERY, STOCKTON-ON-TEES.

This building was erected entirely of concrete stone and pitched-faced blockers and plain quoins, and consists of three floors, the ground floor having a large dining-room

St. Mary's Presbytery, Stockton on-Tees.

24 ft. by 14 ft., study, waiting-room, central hall, and a large kitchen with the usual offices; the first floor has two studies, with bedrooms, bathroom, etc.; the second floor has four large bedrooms.

The roof is covered with green Westmorland slates, and, with the buff-coloured concrete stone, forms a very pleasing effect.

The total cost of the building was £1,250, and it was erected to the order of the Rev. Father Taylorson, of Stockton-on-Tees.

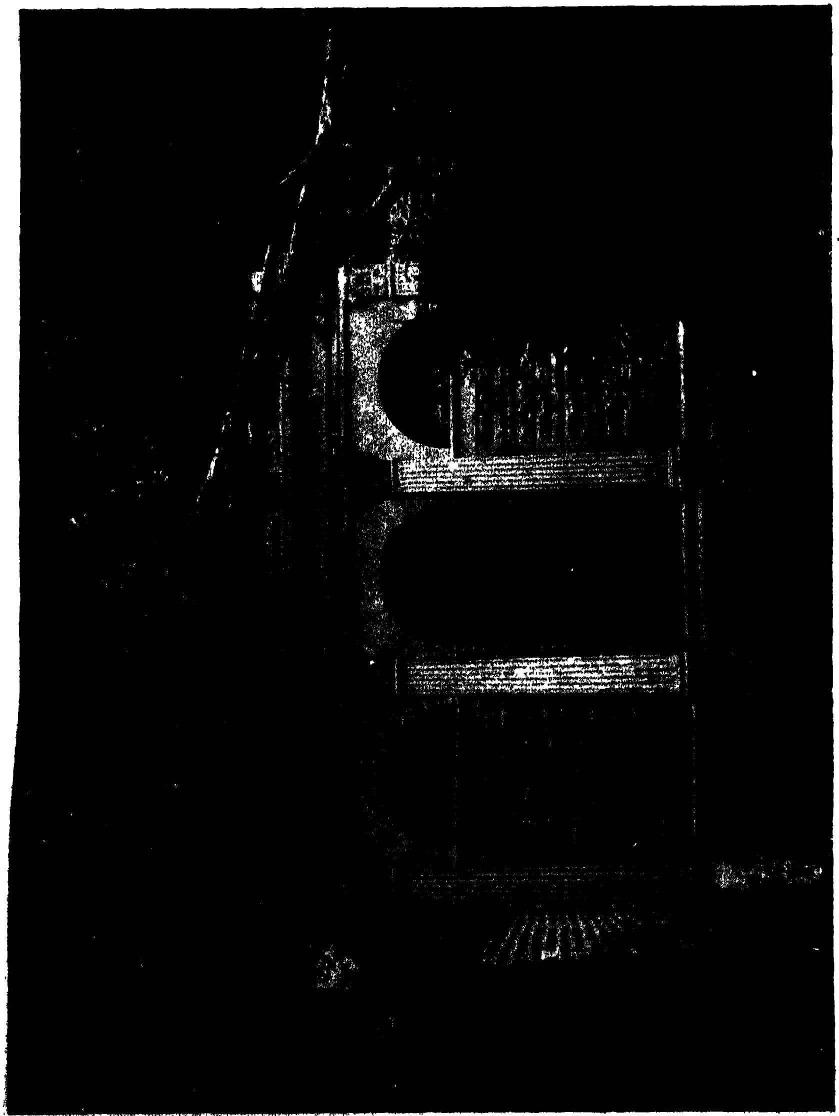
The school adjoining the presbytery was erected about five years ago, and was also built of concrete blocks, and a novel feature of this building is that the playground is on the roof.

PAGODA AT WYNYARD PARK.

This pagoda was erected in Wynyard Park for the Right Honourable the Marquis of Londonderry, and was constructed entirely of concrete stone, having bases, columns with Corinthian capitals, cornice, etc., and in between the columns are rock-face

blocks, while the inside is panelled work with plain ashlar facings. The ceiling also is circular panelled, and is supported on concrete beams. The roof is marbled with white marbled chippings.

The floor, doors, etc., are all made of oak grown on the Wynyard Estate. The



CONCRETE PAGODA, WYNYARD PARK.

whole of the stone for these two buildings was supplied by the Stockton Stone and Concrete Co., Ltd., of Norton, near Stockton-on-Tees, and the blockers, etc., were made by them with the Dring concrete block machine.

Both structures were designed and erected under the supervision of the estate architect, Mr. Arthur Harrison, of Stockton-on-Tees.

NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

"Street Pavements and Paving Materials." By George W. Tillson, C.E.

London: Chapman & Hall, Ltd. New York: John Wiley & Sons. Price 17s. net. 651pp. + xvii.

In his preface the author states that an active participation in the construction of municipal public works, particularly of pavements, during the past twenty years has seemed to justify him in producing this book in order to show the evolution of the modern city street.

With this in view he has given the reader in a concise form a history of road construction, and has presented in an interesting way the results of his own experience in the formation of roads.

The historic portion of the book may be useful as a reference, but will not be much consulted by the engineer. Chapter IV., dealing with Brick-Clays and the Manufacture of Paving Brick, will not interest the British engineer, who discontinued the use of paving bricks some years ago as they were found to be unsuitable for the requirements in our cities. Too much space has been given to the composition of the various rocks and asphaltes, while the chapters on "Cement, Cement Mortar, and Concrete" and "Concrete Pavements" are most useful and contain a great deal of valuable information. It is impossible, however, in two chapters to do justice to these subjects—the author has really attempted too much; we think he might well, for example, have omitted the discussion on "The Effect of Salt Water on Cement Mortar," as one would never dream of using this in connection with concrete for road-making purposes. If "Harbour or Dock Construction" had been the title of the book a discussion of the subject would have been appropriate. The definitions of "lime" and "cement," a description of early cements, and the consumption of cement in the United States might have been omitted and the space saved devoted to a fuller description of the more practical subjects, such as the "Effect of Frost on Mortar" and "Hand *versus* Machine-mixed Concrete."

Mr. Tillson, in dealing with the important subject of concrete pavements, describes the American practice in this respect; this description would have been much more interesting had he inserted a few cross-sections through concrete roads and an occasional photograph showing the various methods of construction; his Standard Specifications for Cement are those adopted in 1909 by the American Society for Testing Materials, and are slightly different from the British Standard Cement Specification.

He quotes too much from trade circulars and specifications in dealing with concrete pavements, and does not go so fully into the merits of concrete as this material justifies, neither does he insert any illustrations showing concrete roads in America. Surely those of New York City, Atchison (Kas.), Eldora (Iowa), Greenville (Illinois), California, and other places might have been referred to.

However, the book is a useful contribution on an important subject. It contains much valuable information put in a crisp manner and to the point, and is a most desirable book of reference for every municipal engineer's office, and should be in the hands of every road-maker, be he contractor or engineer.

There is much that one has not been able to review, there being such a wealth of material in the book that has to be passed by. However, the reader is bound to come to the conclusion that the use of concrete in road construction has undoubtedly come to stay, and will become more and more general.

"A Text-Book on Roads and Pavements." By Prof. Frederick P. Spalding.

London: Chapman & Hall, Ltd. New York: John Wiley & Sons. Price 8/6 net. 408pp.

The aim of the author of this book is twofold—to discuss the principles involved in highway work, and to outline the more important systems of construction.

He is wise in omitting numerous statistics, which are not only uninteresting to the reader, but add to the cost of production of the book, and he has very fittingly devoted considerable space to the methods of construction of country roads, which in these days when rapid vehicles are using all our roads, whether rural or town, make the construction of the country road of as much importance as that of the town.

The book has been written so that it may be understood by those whose knowledge of road construction is extremely limited, and it is easy to realise that the author is used to presenting knowledge in such a form that the engineering student may be able to follow him.

While much that appears in the book is quite elementary to the road-maker—engineer or contractor—there is everything to indicate that the author understands his text.

The book is in its fourth edition, and should be obtained by all interested in modern road construction.

The chapter on Concrete Pavements deals with roads constructed of concrete. The author here deals with such important points as the mixing and laying of the concrete, its consistency, the thickness of concrete necessary, placing of expansion joints, the finishing of the road surface, the quality and strength of the Portland cement used, and many other important points. The chapter is weak, however, in that there is not a single illustration to assist the reader. What the author has to say is put in a clear and readable form. Chapter I. on "Road Economics and Management" is an admirable one for the student, while that dealing with the "Drainage of Roads and Streets," and the chapters on "Road Construction," while they represent American practice, are different from our English methods.

The chapter on "Bituminous Macadam Roads" is very interesting and instructive. Brick pavements occupy a long chapter, but will not interest the British engineer.

The book is an excellent one, written in a language which makes the subject perfectly clear, and by one who knows what he is talking about; the type is good, the few illustrations are clear, but in our opinion the book would have been more valuable had the author included many more illustrations, especially in those parts of the book which deal with modern types of construction, such as concrete pavements.

"The Properties and Design of Reinforced Concrete — Instructions, Authorised Methods of Calculation, Experimental Results and Reports by the French Government Commission on Reinforced Concrete." Translated and Abridged by Nathaniel Martin, B.Sc., etc.

London: Constable & Company, Ltd., 10 Orange Street, Leicester Square, W.C. 119 pp.+xiv, price 8/6 net.

Contents.—Instructions Relative to the Use of Reinforced Concrete—Circular Issued by the French Ministry of Public Works—Draft Regulations by the Commission—The Experimental Work of the Commission—The Report and Draft Regulations of the Experimental Work—Some Conclusions of the Commission—Notes Presented by M. Considère—Appendix.

The French Commission was appointed by the Minister of Public Works in December, 1900, and it consisted of a body of engineers who had excellent experience in reinforced concrete work, and the reports are therefore of great interest and value, especially those dealing with the experimental work.

The work extended over a period of six years, and is of a very complete character, the object being to obtain results immediately applicable to practice rather than the solution of fine points in theory. The tests are particularly useful, as they include the tests to destruction of several of the structures of the Paris Exhibition of 1900, and there is very little evidence of experimental research in this country, although theoretical matter is becoming more or less plentiful. Several facts were established by the Commission as the results of their experiments, some of the points considered being contraction during setting and hardening, elasticity, ductility, the value of spiral reinforcement, shear and torsion flexion; and the designer of reinforced concrete should find the decisions put forward both interesting and instructive.

The notes presented by M. Considère are extremely interesting, as they refer to the methods of making the tests and observations that were made during same with explanatory and instructive remarks.

The theoretical portion of the volume is also good, and the diagrams throughout are clear and well drawn.

"Building Construction (Advanced and Honours Course)." By Chas. F. Mitchell, M.S.A., etc.

London: B. T. Bateford, 94 High Holborn. 940 pp.+viii, price 6/-.

Contents.—Limes and Cements—Concrete—Asphalt — Plastering — Stones—Bricks—Tiles, Terra-cotta and Stoneware—Iron and Steel—Timber—Paints and Varnishes—Glass—Foundations — Brickwork — Flues, Fireplaces and Tall Chimneys—Masonry—Carpentry—Half-timbered Work—Pillars, Columns and Stanchions—Graphic Statics—Girders—Fire Re-

sisting Construction—Reinforced or Ferro-Concrete — Roofs and Roof Coverings — Joinery — Stairs and Handrails—Sanitation, Water Supply —Hot Water Apparatus and Ventilation—Electric Bells and Lighting—Exercises—Appendix and Examination Papers.

This is the seventh edition of what is probably the most popular book on building construction in this country, forming as it does the text-book in many technical schools where the subject is taught. It contains about eight hundred illustrations, and covers practically the whole subject of construction in a manner designed to meet the requirements of students. Although an excellent book, we feel that there are some points which should be drawn to the notice of the author, as, for example, the diagram shown in the illustration No. 134, page 278, where the concrete under an 18-in. wall is only figured 3 ft. wide. This should be the width of the footings, and the concrete should be 4 ft. Such an error is calculated to cause the unwary student some trouble if the diagram should be drawn as shown, commencing with the concrete and working upwards, when the wall will work out to 6 in. thick only. The method of finding the depth of concrete under walls described on page 260 and illustrated on page 261 is not good, as it gives an excess not required. A better method is to let the line at 45° from the top of the footings intersect a vertical line drawn from the opposite extreme projection of the footings. This method will give results more in accordance with those obtained by calculation. The grillage foundation illustrated on page 267 is obsolete, and no distance pieces, stiffeners or bolts are shown or mentioned. The chapter on fire-resisting construction might with great advantage be revised and amplified to bring same more in accordance with modern methods, especially in view of the great importance of this class of work. The concrete and steel floor illustrated in *Fig.* 395, page 581, is quite unsatisfactory, the filling in joists being inadequate for the span mentioned and the concrete not being thick enough. The floor illustrated in Fig. 396 consists of steel troughs carried by plate girders, and the author suggests that the space under the troughs can be utilised for pipes or even ventilating purposes, but evidently overlooks the fact that to do this the webs of the plate girders would have to be cut away in such manner as to seriously weaken them. The chapter devoted to reinforced concrete has rightly been extended, and should be sufficient to give the student an idea of the use and value of this material. We are sorry to see, however, that the portion devoted to concrete is not more complete. Machine mixing is simply mentioned as an alternative to hand mixing, but no description is given, and no diagram or illustration of any of the well-known mixers appears, and this must be considered as a serious omission, as they are used on practically all important work. The portions devoted to graphic statics and calculations for pillars and girders occupy a considerable space in the volume, but they are very vague in many instances, and we doubt the ability of many students to follow the author or profit by the study of these chapters sufficiently to justify the large amount of time it would involve. If the author and his assistants would devote their attention to perfecting the work to comply with modern practice and delete many of the diagrams and much of the text which deal with more or less obsolete methods, there is no doubt that the effect would be the production of an almost perfect volume dealing with the very large subject of building construction. These remarks are merely given as the outcome of an honest criticism and a desire to assist the author.

INDUSTRIAL NOTES.

These pages have been reserved for the presentation of articles and notes on proprietary materials or systems of construction put forward by firms interested in their application. With the advent of methods of construction requiring considerable skill in design and supervision, many firms nowadays command the services of specialists whose views merit most careful attention. In these columns such views will often be presented in favour of different specialities. They must be read as ex parte statements—with which this journal is in no way associated, either for or against—but we would commend them to our readers as arguments by parties who are as a rule thoroughly conversant with the particular industry with which they are associated.—ED.

SEPARATORS.

(System Von Grueber.)

WHENEVER it becomes necessary for users of crushing and grinding machinery to consider new installations or additions to existing arrangements, the question of an efficient method of separation is one of several problems requiring careful consideration.

First, the system must be decided. Screen-type or air (pneumatic); secondly, which of the two types of design will best suit the particular material and circumstances of the user.

As most practical people know from experience one type or design of separator will be the greatest success on one particular material; whereas, on the other hand, it will turn out an utter failure on a different class of product. The present article deals with the separators of Messrs. C. von Grueber, 31-33 High Holborn, London, W.C., who are extensive manufacturers of the Screen and Air type separators (under several accepted designs).

The Screen Type of Separator.—This firm can offer a separator designed to have screens supported or carried by springs or rods, and to which motion is imparted by tappets, cams, cranks or eccentrics. Certain materials require a combined sliding and shaking action, others merely a tapping motion; while there are materials upon which it is necessary to operate by a rocking screen sometimes combined with tappets.

A feeding screw arranged within a specially designed case is always employed for equally distributing the material along the full width of the screen, and a simple device is utilised for regulating the flow along and down the screen.

The screens are carried in a strong steel casing, provided with inspection doors for the feed screw and the screen meshing, while the whole front and back of the casing may be opened on hinges whenever it is necessary to remove the screen for cleaning purposes or to renew the meshing, the situation of the separator deciding whether it is more convenient to use the front or back opening.

Any number of screens may be fixed in the casing according to the various samples desired, but usually the separator is provided with a guard screen in addition to the finishing screen. This arrangement relieves the finer screen from contact with a great proportion of the bulk passing through the machine which has no possible chance of passing through the meshing of the bottom screen.

Of course, a certain amount of the ¼-in. and less product must be allowed to pass the guard screen to the finishing screen, for the purpose of "scouring" the finer meshing—that is, to keep the holes of the meshing free and unobstructed; but the additional effect is obtained of assisting the fine product through the fine meshing, thereby reducing to a minimum the possibility of any finished product passing out with the tailings or residue.

We think one, if not the leading feature, of the separator here under review is the fact that the body or casing of the machine need never be altered in position once it is fixed, because the angularity, and consequently the fineness of the finished product, may be instantly determined by fixing the position of the finishing screen from the outside of the casing.

To practical minds such an arrangement will be self-evident, inasmuch as it does away with the necessity of breaking the connection of the chutes leading to and from the separator casing, which it is impossible to obviate if the casing must be moved up and down supporting legs to change the fineness of the finished product.

It is claimed that the screen separator is a great advance upon the revolving, flat, or ordinary shaking sieve or dressing machine, because with the former type a very coarse meshing is only necessary to obtain a relatively fine product; for instance, suppose a finished sample is required, 80 per cent. of which must pass the 100 by 100 test sieve (10,000 holes per sq. in.), then it is only necessary to use meshing having about 34 by 34 holes per sq. in.

Again, by using coarse meshing the wire from which it is woven is proportionately increased in diameter and strength, thereby ensuring increased life and less cost for the upkeep of the meshing.

The coarse meshing also ensures an increased output of finished product, from the fact that the difficulty of the clogging of the mesh is largely removed.

The residue makes exit from the bottom edge of the machine through an opening extending the full width of the screen and usually delivering to a store-bin over the grinding mill; while the finished product gravitates down the bottom of the casing to an opening under which is fixed a conveyor for transporting the fine material to any desired point of delivery.

Usually the conveyor is a main line of transit to the stores or silos, but in special cases a short conveyor is combined with the separator and is driven from the shaft of the feeding screw.

A pulley at the opposite end of the feed screw drives the machine and all the operating gear and mechanism.

The screen separators are made in several sizes to correspond with a given output or capacity, and the horse-power required is ¼ for the smallest machine up to 3 h.p. for the largest size.

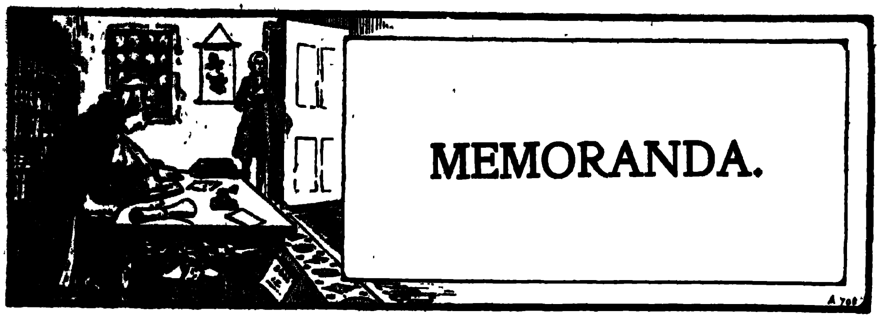
In many cases—particularly where an exceedingly fine and " floury " product is required—it is impossible to use the " Screen " type of separator, and under these circumstances the " Air " or pneumatic type of separator must be requisitioned.

" Air " or Pneumatic Separators.—These machines are made in sizes ranging from 3 ft. 6 in. to 10 ft. diameter, and requiring from ⅛ to 6 h.p. for driving purposes according to size.

In conclusion, we may be allowed to point out that Messrs. C. von Grueber are sole manufacturers in Europe of the well-known " Maxecon " ring and roll grinding mill; and, in addition, the firm also make and supply all types of crushers, elevators, conveyors, automatic feeders, dust collectors, rotary screens, etc.

They also undertake to act as engineers for the re-construction of existing or the supply of new sulphuric acid plants, designed upon the latest and up-to-date Continental systems.

The Maxecon mills, intended for use in Great Britain and Ireland and the Colonies, are manufactured in England from the best English materials.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Repairing St. Paul's.—The work of repairing the cracks in St. Paul's Cathedral has been commenced. The method employed will be cement grouting. A thin liquid of cement is forced into the cracks by means of a special machine, worked by compressed air and so forming a solid weld between the two sides of the crack. This process proved very successful in the repairing of Winchester Cathedral.

Reinforced Concrete in the Protection against Hostile Aircraft at the New Naval Magazines, Portsmouth.—The new naval magazines for the storage of high explosives at Portsmouth are being most effectively protected against hostile aircraft. They are situated at Bedenham and consist of a number of sunken reinforced concrete chambers completely covered so as to keep their identity hidden from above.

A reinforced concrete pier is also being built for the use of small craft only, and a network of rails will enable the explosives to be conveyed direct to the magazines.

Purification of Water Supply, Aberdeen.—In connection with the purification of the city's water supply the Water Committee recently decided that the reservoir of Mannofield and Cattofield be covered with reinforced concrete.

Improvements at Havre, France.—In connection with the harbour improvements at Havre it is reported in *The Times* Engineering Supplement, that the existing southern jetty is to be greatly extended. This extension is to be in two parts, one comprises a section of 1,445 m. long constituted by a number of reinforced concrete caissons measuring 25 m. in length, 6 m. in width, and 5·75 m. in height, and the other 1,700 m. long formed with similar caissons in length and width, but 6 m. high.

Reinforced Concrete for Coal Tips.—In order to meet the growing demand for coal shipment and to avoid the necessity for dock extension at present, the Barry Railway Co. have decided to erect five new coal tips on the south-western side of No. 1 dock. The supports to these tips are to be in reinforced concrete. In the older tips wooden supports were used, but it has been considered that, owing to the reduced cost in maintenance, reinforced concrete would prove more suitable.

Merrion Pier Scheme, Pembrokeshire.—After careful consideration and discussion, and upon the advice of their engineer, the Committee appointed for the Merrion Pier and Baths scheme recommended the Pembroke Urban District Council that it would be desirable to have the entire pier constructed from end to end in reinforced concrete, and, subject to the sanction of the Local Government Board, it was recommended that the tender for this work be accepted, as also the tender for substituting reinforced concrete for repairs to the existing pier.

A Proposed Scheme for Working-class Housing.—In a paper read by Mr. B. Wyand at the joint meeting of Western and South-Western Districts of the Institution of Municipal Engineers at Exeter some time ago, Mr. Wyand gave some particulars of a scheme for working-class dwellings which is under consideration. The proposed building is to be erected in Mile End on a site of 4½ acres, and is to have accommodation for 5,550 tenants. The building will be of fire-resisting construction throughout, with fire appliances on every floor of every block, and reinforced concrete will be used very largely in the construction.

Tables of Reinforced Concrete.—It is reported in the *Tonindustrie Zeitung* that a manufacturing firm had recently made an experiment in using reinforced concrete workshop tables in place of cast iron ones. These tables have proved more economical to make, and they can be made very much quicker than the iron ones.

The latter cost about 420 marks to make, and delivery could only be made at between three and four weeks when single orders were placed. On the other hand, the reinforced concrete tables can be made at a cost of about 180 marks, and three tables can be turned out in a week ready for use.

The top of the table is reinforced with an angle iron framework, and the ten legs, which each table has, are also reinforced and joined to the table top by T-irons. The tensile stress is taken up by six 16 mm. round iron bars which are joined to the framework. In order to protect the edges of the table a narrow angle iron, 30 mm. by 45 mm., has been put round same.

The cement mixture consists of Portland cement and unsifted, but not too coarse, gravel in the proportions of 1 : 4, and the top surface of the table consists of one of Portland cement and two of sand.

Before setting, granite and fine basalt are beaten into the top, which is then covered with neat cement. After proper hardening the table top is smoothly and evenly rubbed down.

The tables stood a test weight of 5 tons without being damaged in any way, and even heavier pieces of work did not harm them.

The Society of Engineers' Status Prize.—The Council of the Society of Engineers (Incorporated) may award in 1913 a premium of books or instruments to the value of £10 10s., for an approved essay on "A scheme for the registration of Engineers, including particulars concerning the registration of Engineers in British Colonies and foreign countries." The Council reserve the right to withhold the premium if the essays received are not of a sufficient standard of merit. The competition is open to all, but, before entering, application for detailed particulars should be made to the Secretary, 17, Victoria Street, Westminster. The last date for receiving essays is May 31st, 1913.

Concrete Rockwork at the Zoological Gardens. — The improvements at the Zoological Gardens, which are the outcome of a gift to the Zoological Society by Mr. J. Newton Mappin, head of the firm of Messrs. Mappin and Webb, are to comprise a number of terraces and rockwork, which latter is to be constructed of steel and concrete, and we hope in a future issue to give some further details of this work.

Large Reinforced Concrete Cotton Warehouses in U.S.A. — The Galveston Cotton Compress and Warehouse Co. are about to erect a reinforced concrete cotton press and warehouses to cover an area of nine acres at a cost of approximately £82,000. Some of the work is to be completed by July 1st next.

Locomotive Coaling Station.—A locomotive coaling station of reinforced concrete of 2,000 tons capacity, spanning seven tracks, has recently been completed at the Green Street yard of the Philadelphia and Reading Railway, at Philadelphia, in connection with track elevation work in and about the city.

The building is supported on seven rows of five columns each, and one end walk transversely, the rows of columns being placed parallel to outer lines of tracks. The floor of the pockets is of sufficient height above the top of rail to permit the largest engines to take on coal and dump ashes. The framework of the building is of structural steel and the walls, partitions, and floors of coal pockets are of reinforced concrete. The building is divided into twelve pockets equipped with two coal chutes each, and machinery for handling 100 tons of coal per hour. The ash handling machinery has a capacity of 250 yds. per ten-hour day.

Coal is dumped from cars into a hopper located below the track at the west end of the building, from which it is elevated and distributed to the pockets by machinery installed by the Link Belt Co., the contractor for the station.—***Railway Engineering.***

San Francisco Station.—H.M. Consul-General at San Francisco reports to the Board of Trade that, according to the local Press, the Southern Pacific Railway Co. propose to spend nearly 1,000,000 dols. (about £205,500) on a new terminal station at San Francisco. The new station will be two storeys high and built of reinforced concrete with a tiled roof.—***Contract Journal.***

Producing Polished Effects on Concrete Work.—Concrete slabs and brick are now being produced that are as fine in grain and structure as high-grade porcelain, showing an equally fine polish. The secret of the process consists in grinding the aggregates to as fine a powder as the cement. The mixture, one cement to as high as twelve of aggregate, is then dampened just sufficient to pack well when pressed in the hand. It is then subjected to high pressure in strong iron molds, up to 5,000 lb. per sq. in. The best results are obtained in slabs or plates slightly under 1 in. thick. The pressure is applied in four or more strokes. After each stroke the pressure plate is removed to permit the air to escape. After each stroke the pressure is increased. The object of grinding the aggregates to the same fineness as the cement is to prevent forming an arch in the stone, which always takes place where high pressure and coarse aggregates are employed. Then, again, if the pressure applied to the concrete exceeds the crushing strength of the aggregates, the aggregates will grind at the contact point in the mass, leaving powdered contact points which weaken the concrete. This defect is entirely overcome by using a fine powdered aggregate. It will be seen that high pressure and coarse aggregates are inconsistent for fine work. Coarse aggregates can, however, be used where the mould produces forms in the shape of an arch, and the pressure applied is below the crushing strength of the aggregates. It is extremely bad practice to use high pressure in moulding concrete blocks over 4 in. high, on account of the danger of the arching of the aggregates. Tamping square or hollow concrete blocks is always to be preferred for sound work.—*Cement.*

Specification for Cement-top Floors.—The Aberthaw Construction Co., Boston, specify as follows for cement-top floors. This specification is for laying hard finish on new rough concrete, either paling or slabs supported by forms.

Finish to be mixed one part of cement to two parts crushed trap rock or hard gravel screening, which will pass through a ½-in. sieve, and from which the fine dust has been removed. This is to be thoroughly mixed in a mixing box or by a machine mixer, with an amount of water to produce a plastic but not a sloppy consistency; spread on the under-concrete before either the finish or the under-concrete has had time to set, floated with a wooden float to a true level and then lightly trowelled with a steel trowel as soon as possible to bring it to proper level and to smooth the top slightly. This will give a finish which is pebbly. It will not be dead smooth or slick like a sand finish.

After the finish has been trowelled and has set sufficiently so that the covering will not mar the surface, it should be covered with sawdust, sand, cloths, or any other material which will hold water on it continuously. In building reinforced concrete work, difficulty will be caused by the sand and sawdust blowing about the work, filling the forms, and generally getting in the way. In working around a textile mill there is usually plenty of old bagging, and in a paper mill there are usually plenty of old felts which can be borrowed for the purpose of preventing this.

The finish should be kept soaking wet for at least a week or better for ten days. After two days it is possible to put up studs and do miscellaneous work on the top of the new finish, provided it is not allowed to dry out.

Concrete in Mine Air-ways.—The use of concrete in mining may be extended to replace timber in airways. The roof of most coal mines is formed of shale, which deteriorates rapidly where exposed to the weather, thus necessitating a large amount of timbering in entries. If this weathering could be overcome, little timbering would be necessary. This has been done by the Bethune Co., of the Pas-de-Calais district, of France, by lining their gangways with reinforced concrete made of burned shale, boiler ash, cement and water. This mixture requires fifteen days to set. The reinforcement consists of 4-in. arched rods, placed 32 in. apart, and further strengthened by round ½-in. rods, placed lengthwise, 9 in. apart. Not only does this method reduce the cost of timbering, but it prevents interruption in hoisting, due to falls of roof; watering can be easily and thoroughly done; lighting is good, as the walls are light coloured, and danger due to falling roof when timbering is destroyed by a runaway trip is absent.—*The Concrete Age.*

Temperature Changes in Concrete when Setting.—A paper read by W. D. Maxwell before the Iowa Engineering Society sets forth some interesting and

important data on the temperature of concrete during setting. Tests were made during work on Des Moines river concrete bridge. The observations were made in various parts of piers and abutments composed of 1 : 3 : 6 concrete, with thermometers placed in pipes set in concrete. The points where readings were taken were from 3 to 10 ft. from surface and face of concrete. The temperatures recorded show an increase of 15 degrees to 20 degrees Fahr. above temperature at time of pouring, in the concrete mass during setting, the maximum being reached in seven to ten days after pouring. Then the temperature falls, the rate depending on outside temperature. This risk in temperature was shown to be substantially the same, regardless of outside temperature, some of the tests being made in freezing weather and others during summer.—*The Concrete Age.*

Disadvantages of a Hardwood Floor over Concrete. — In speaking of the disadvantages of a hardwood floor over concrete, Leonard C. Wason, president of the Aberthaw Construction Co., Boston, remarked that besides the cost there is the added dead-weight of the screeds, cinder fill, under floor, and upper floor. Dead-weight adds to the cost of the supporting construction of the foundations and adds other cost besides that of the floor itself.

Tar and Cement Pavements in Germany.—Experiments have been made in Bremen and elsewhere with a street pavement composed principally of tar and cement, and which is called "terbacca."

A test section at the Oldenburg freight station shows, after two years of heavy traffic, but little surface wear and no cracks, although laid on filled ground.

The tar-cement pavement is laid on a bed of 5 in. to 6 in. of concrete, or over broken stones slicked with cement mortar, say about 2 in. or 3 in. for ordinary streets, ¾ in. to 1½ in. for foot pavements, and 1¼ in. to 2 in. for courts. The mixture is made up of ninety volumes of hard, broken stone of three different sizes, ten of gravel and sand, and forty to sixty of Portland cement, mixed dry, then 10 per cent. of water is added, and at least five parts of coal tar, thinned down with a solvent. The tar-cement mixture is laid on much more quickly than required finally, and tamped down with a 6-lb. rammer to the required thickness. Where grades are unusually steep more cement is used than on levels.

To prevent the formation of cracks, it is sufficient in ordinary climates to leave openings of ⅝ in. every 40 ft., filling these with asphalt.

In Gothenburg, Sweden, and on the Kaiserstrasse in Hagen, Wesphalia, this pavement has done well; and in the latter city the tar-cement covering is only 7 cm. (1·78 in.) thick, but a week after its laying it is run over by a steam roller without showing any signs of ill-usage. Here the grade is 1·60.

In the matter of impermeability, after subjecting plates 1 cm. to 2 cm. (0·394 in. to 0·788 in.) thick to water columns in glass pipes 2 m. to 2½ m. (5·56 ft. to 8·2 ft.) long for six weeks, the under sides of the plates were not wet.—*The Contract Record.*

A Concrete Scow.—A reinforced concrete scow for towing purposes on the lake has been built in Michigan City, Ind., says the *Concrete Age.* The craft will have a carrying capacity of 25 tons, and will be 14 ft. by 40 ft. by 3 ft. 6 in. The walls will be 3 in. and strongly reinforced. Only the deck plankings and fenders will be of wood. The life of a concrete scow will be much longer than that of a wooden one, and the concrete will stand a greater shock than a 6-in. timber.

Concrete Floors for Foundries.—A number of experiments have recently been made which show that if iron borings are used in place of a portion of the gravel mixed in concrete, floors of this material can be successfully used in certain portions of foundries. Many foundrymen are interested in the use of concrete floors, but have generally found them unsatisfactory because molten iron will not lie on concrete on account of its porous, and, therefore, generally moist condition. The mixture recommended consists of one part cement, three parts sand, four parts gravel, and one part of iron borings. It is stated that floors made from this mixture are perfectly safe.

A Reinforced Concrete Office and Factory Building.—An interesting example of the adaptability of reinforced concrete, for an office and factory building, is that afforded by the recently erected structure of the Gillette Safety Razor Co. of Canada, Ltd., Montreal, P.Q.

The structure contains about 50,000 sq. ft. of floor surface, its outline being

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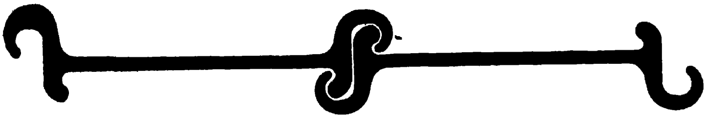

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irregular. The longer sides are 122 ft. and 105 ft., while the building is five stories high with basement.

The suitability of reinforced concrete to architectural treatment is here well illustrated. On all exterior concrete above the belt course, a smooth surface was obtained by rubbing with carborundum blocks, while below this point the concrete was bush-hammered.

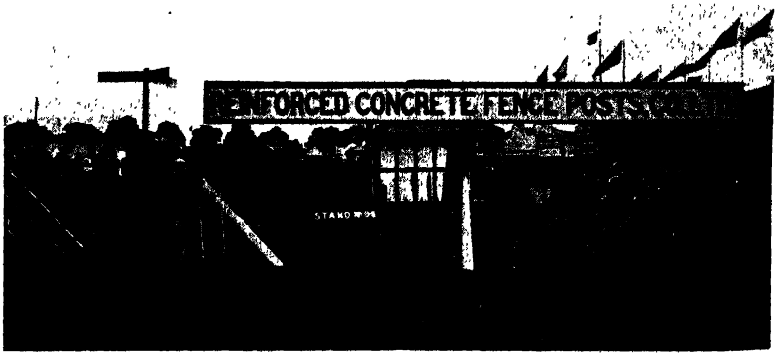
The flat slab or girderless floor system of construction was used in this building, thereby eliminating beams, which tend to cut down the headroom, obstruct the light, and gather dust and prevent the satisfactory operation of automatic sprinklers, with which this building is entirely equipped. The column spacing is 20 ft. by 16 ft. 10 in.

The reinforced concrete floor slab for the first floor is 9½ in., but the other floors are 8½ in. thick. The finished floor in each case is a 1-in. maple top on 3 in. by 4 in. screeds, 16 in. on centres, embedded in 3 in. of cinder fill. The height of stories is 11 ft. 6 in. from floor to floor.

This building was designed by Lockwood Greene and Co., Boston, Mass., and the general contractors were the Atlas Construction Co., of Montreal.

Recent Reinforced Concrete Works in Alexandria.—Our attention has been called to the fact that the reinforced concrete pontoons illustrated in the above article in our January issue, pp. 25 and 26, were according to Hennebique designs.

Reinforced Concrete Fence Posts.—In further reference to the remarks in our January issue regarding the use of concrete at the Doncaster Agricultural Show, we give herewith an illustration of some fence posts erected at that exhibition by the Reinforced Concrete Fence Posts Co., Ltd. This company is now erecting fences or supplying the materials for their erection to seven of the principal railways of England, Metropolitan Water Board, Port of London Authority, and many private estates. There is often a great deal of prejudice to overcome in the introduction of a new



Reinforced Concrete Fence Posts at the Doncaster Agricultural Show.

material, but the advantages of these posts as compared with wooden ones have been dealt with by us in former issues, and their almost universal adoption seems to be only a matter of time. Reinforced concrete will neither rot nor burn; in fact, the posts are benefited by wet or sodden ground, as the moisture assists in the chemical action which takes place in the hardening of the Portland cement. Cement with adequate reinforcement and specially graded aggregates, all carefully manipulated, insures a monolithic casting of the greatest strength. The company are also manufacturers of railway gradient posts, mile posts, and concrete lettering, etc.

TRADE NOTICES.

River Trent Protection Works—Reinforced Concrete Construction.—The City Corporation of Nottingham has accepted the tender of Messrs. Gibbons and Turner, of Nottingham (licensed contractors for the "Piketty" system of reinforced concrete), for the execution of the above, in accordance with the plans of Mr. Arthur Brown, M.I.C.E., City Engineer.

The whole of the work is to be carried out on the "Piketty" system of reinforced concrete construction, which has been selected in competition. Full particulars of this method can be obtained from Messrs. Piketty, 14-18 Bloomsbury Street, W.C.

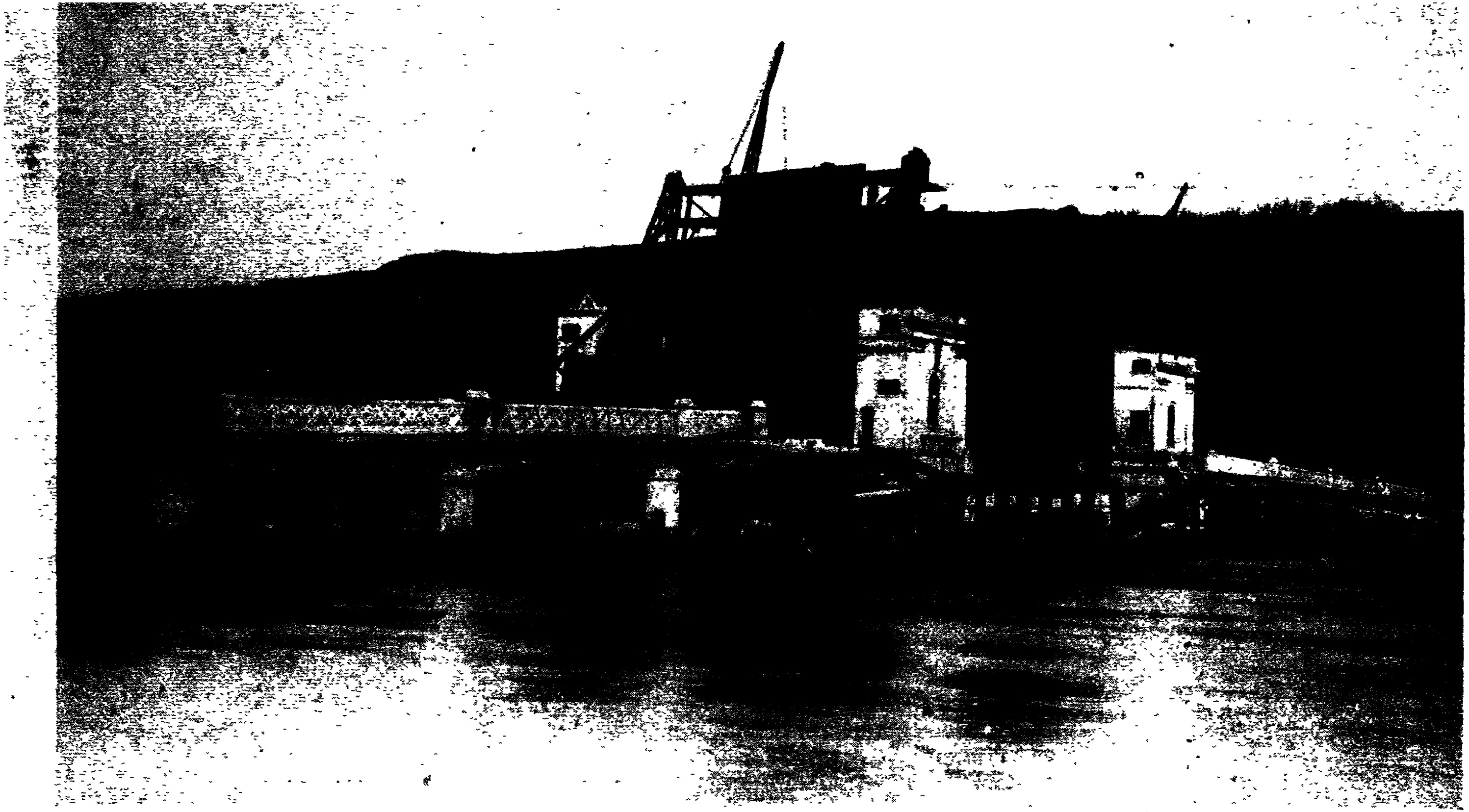
ENQUIRIES.

I would be much obliged if you would kindly advise me through your valuable paper as to how to remedy and repair concrete girders, beams, and columns which have been cracked by electrolytic corrosion, just as per the very interesting article and photos by Mr. Cecil H. Desch, D.Sc., Ph.D., in your journal of November, 1911, Vol. 6, No. 11. (Signed) ANGLO-INDIAN.

To the Editor, *Concrete and Constructional Engineering*.

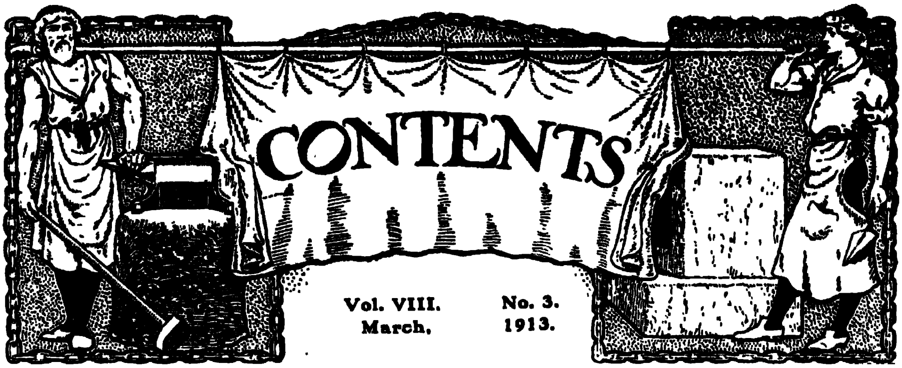
REPLY.

All damaged concrete should be cut out, exposing the reinforcing rods, which should then be scraped clean. It is assumed that the damage has not gone so far as to eat away the metal to any appreciable depth. In making good the concrete, a rich cement mixture should be used, the aggregate being broken small enough to pass a ¾-in. mesh and mixed with sand in the best proportions to give a dense concrete. The denser the concrete the better. Of course, the usual precautions must be taken in joining the new with the old work.



View of Bridge practically Completed.

THE WATERFORD BRIDGE.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CONCRETE & CONSTRUCTIONAL ENGINEERING

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume VIII. No. 3. LONDON, MARCH, 1913.

EDITORIAL NOTES.

CONCRETE ROADS.

ALTHOUGH concrete is gaining a firmer foothold in this country and its use is becoming more general for all manner of buildings, it seems extraordinary that, comparatively speaking, so little study has up to the present been given to the question of its employment on our roads.

The use of heavy motor traffic is on the increase and is causing considerable anxiety to those who have charge of the maintenance and building of our roads and highways; and although many experiments have been made to discover the most suitable material from the point of view of economy in construction and maintenance, a final solution has so far not yet been arrived at.

In our present issue we publish an article by Mr. E. R. Matthews, Borough Surveyor of Bridlington, on "Concrete Roads and Footways," which goes to bear out in some measure the experience acquired in the United States. In America concrete is being employed on a large and extensive scale for highways, and most of the literature seems to go to prove that the material has many advantages, viz., to enumerate one or two only: the construction is not difficult, the roads cost little to maintain, and they are smooth. On the other hand, like everything else, there are some disadvantages attaching to its use, but these, we hold, are far outweighed by the accruing gain, and, what is more, as has been proved in American practice, these difficulties can be overcome.

One of the disadvantages mentioned by Mr. Matthews—namely, that these roads are inclined to be slippery—does not seem to be borne out by many motor users in America whom we have consulted, for, evidently in order to avoid this trouble, American engineers have recently adopted the practice of rendering the surface slightly gritty. Further, the tendency to crack, which is one of the alleged disadvantages, is apparently also one that can be easily remedied.

We propose publishing some American experiences in our subsequent issues, and would recommend that our county and borough surveyors and our municipal engineers should accord this question of concrete roads greater attention.

In conclusion, we venture to express the hope that at the Road Congress to be held this summer the subject will be given some prominence, and that the problem of special motor roads on the main routes of communication may be discussed.

ROAD BRIDGES OF REINFORCED CONCRETE.

AT the present time, when so many of our provincial corporations and county councils are considering the question of reconstructing old bridges or building new ones, a few words on this subject may not come amiss.

We have read with considerable interest in the daily Press the accounts of the proceedings of the various corporations when debating the advisability or non-advisability of erecting or reconstructing bridges in reinforced concrete.

A case in point is the cross-river communication at Newport, Monmouthshire. The question of a new bridge or the reconstruction of the old one has for some time past occupied the attention of the Newport Corporation, and we observe that members of the Town Council seem very apprehensive of replacing the present masonry bridge by one in reinforced concrete, or even building a new one in that material. From quite recent information before us we note the recommendation of a resolution to rescind a former resolution to erect a bridge in reinforced concrete and that the sub-committee be empowered to confer with an expert with a view to adopting plans for constructing a stone bridge, and this, we believe, after matters had so far progressed that plans for a reinforced concrete structure had been drawn out.

Similarly, in Norfolk, where quite a number of bridges of concrete are already under construction or completed, it would appear that some of the members of the County Council are doubtful as to the ultimate success of the venture, and a short time ago a hope was expressed by some that nothing larger than the Coltishall Bridge now under construction—consequent upon the floods of last year—would be undertaken in reinforced concrete.

It seems to us that surely these doubts and fears are somewhat groundless—given, of course, that all due care is taken in the designing and carrying out of the work. These are, of course, absolute essentials; without them, failure might equally well result with any other form adopted.

In the United States and on the Continent bridges of far greater magnitude and span have been carried out in reinforced concrete, and have not only proved a success from the practical and economic point of view, but many of them are of artistic merit, and those of our readers who have read our journal regularly will no doubt have seen the numerous illustrated articles on such structures carried out abroad. We would mention also the new reinforced concrete bridge 762 ft. long opened early last year in New Zealand over the Ruamahunga River near Featherstone.

In our own islands the Waterford Bridge, 700 ft. long, on which an article appears in this issue, should not be overlooked. We could quote many other examples if space permitted.

In conclusion, we would only express the hope that the fears of those who have such work under consideration may be allayed after a careful study of the matter.

As before repeated, with careful designing, good workmanship and supervision in construction, careful selection as to the reinforcement best suited for any particular structure, and care in the mixing of the concrete, bridges erected with this material will not only prove satisfactory, but be more durable and will cost less to maintain.

BELGIAN NATURAL CEMENT.

Some interesting new departures have been made in the new specification issued last year by the Administration of the Belgian State Railways, which will in future govern the acceptance and testing of Portland cement for all works carried out for that Department.

The new regulations require that all cement supplied shall be slow-setting, and may be manufactured by any method so long as it complies with the following requirements:—

(a) The chemical composition shall be such that the proportion of magnesia

(MgO) shall not exceed 3 per cent.; that of sulphuric acid (SO_3) shall not exceed 2½ per cent.; and that of the insoluble residue shall not exceed 1½ per cent.

(*b*) No slag or other foreign matter may be added to the cement except such proportion of plaster as may be necessary to regulate the setting time.

(*c*) The loss on ignition shall not exceed 3 per cent.

(*d*) After calcination the cement must not contain less than 61 per cent. of lime (CaO).

(*e*) The fineness shall be such that the residue on the sieve of 76 meshes per square inch shall not exceed 5 per cent.

(*f*) The cement shall not commence to set in less than 45 minutes after gauging, nor be complete in less than 4 nor in more than 14 hours.

(*g*) The specific gravity must not be less than 3·07.

(*h*) The tensile strength of sand briquettes (3 of normal sand to 1 of cement), after 24 hours' hardening in moist air and 6 days' immersion in water having a temperature ranging between 59 and 64½ Fahrenheit, shall not be less than 184½ lbs. nor less than 284 lbs. per square inch after 27 days' immersion.

(*i*) Pats of neat cement gauged on glass plates shall, after 21 hours' hardening in moist air, be subjected to a steam bath, in which the temperature of the water shall be gradually raised so that at the end of the first hour it shall not exceed 176 Fahrenheit, after which it shall be raised to boiling-point and maintained thereat for 5 hours. The pats must not show any cracks or distortion after this test.

In any case of doubt concerning the quality, the officer in charge may require compliance with additional tests as under:—

(*j*) The compression strength for mortar cubes (3 to 1), after 24 hours' hardening in moist air and 6 days' immersion in water having the same temperature as for the tensile tests, shall not be less than 1,846 lbs. nor less than 2,840 lbs. per square inch after 27 days' immersion.

(*k*) The Le Chatelier test shall not show an expansion greater than 6 millimetres.

The officer in charge of the work is, however, given discretion to accept cement which falls slightly below the foregoing requirements, provided, however, that in no case the specific gravity be less than 3·07, the tensile strength less than 156 lb. and 227 lb. respectively at 7 and 28 days after gauging, and the compression strength not less than ten times these figures, but in such cases an extra quantity (not less than 25 per cent.) of cement must be used.

The Administration has also issued supplemental regulations defining the methods by which each test shall be carried out. These exhibit a desire to ensure great care and absolute uniformity in the work. The diameter of the sieve wire is defined, the exact method of determining the specific gravity is prescribed, the manner of ascertaining the "normal consistency" of the mortar by a needle instrument is carefully regulated, the grain or texture of the normal sand is also provided for, the setting time is to be determined by a needle of given weight and dimensions, the size and thickness of the test pats is carefully fixed, and the method of gauging the briquettes and cubes is also strictly regulated. In this last-mentioned detail the Belgians have chosen to

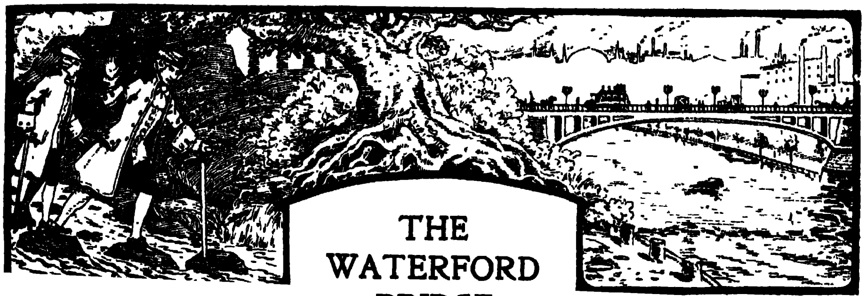
copy the German example rather than the English. In the British standard specification, as is well known, it is stipulated that the gauging shall be done entirely by hand, and the mortar pressed into the moulds without mechanical ramming; but the Germans adopted mechanical ramming as the standard method more than a quarter of a century ago, and, after prolonged experience of it, remain convinced that, though it may differ in greater degree from the conditions obtaining in actual practice than when the work is done entirely by hand, the advantages of uniformity of handling (as between each individual sample tested) more than outweigh the theoretical objections, and they have therefore retained the mechanical principle in their new normal specification issued rather more than a year ago. The Belgians have now followed suit, and stipulate for the ramming of the briquettes by 120 blows from a hammer weighing 2 kilogrammes falling from a height of 25 centimetres, and for the ramming of the cubes by 150 blows of a hammer weighing 3 kilogrammes and falling from a height of 50 centimetres. The briquettes are to be broken in a Michaelis machine, but no special make of machine is named for the compression tests.

It will be noted that a minimum lime content is insisted on, and, when taken in conjunction with an absolute minimum specific gravity of 3·05, even when the extra proportion of cement is a condition of permission to use it, this will effectually exclude the so-called "natural cements" from use on the State railways of the country of their origin. As it can hardly be supposed that the Government engineers refuse to avail themselves of these cheap national products without good reason for such a course, their example should command the careful attention of every professional man. If Belgian "natural cement" is not good enough for use by the Belgian public authorities, how can any of our readers dream of accepting it for use outside its native land? And yet we hear now and then of a few officials who remain indifferent alike to the Belgian Government's own example and to the teachings of experience, and take no pains to insist on their contractors using only genuine *artificial* cement—the only material entitled to the description of "Portland cement"—on work under their control. A word of caution on this point is just now especially necessary, in view of the fact that, owing in part to the higher cost of materials, fuel, labour and freight rates, and in part to the end of the prolonged depression and a closer balance between production and consumption, the market price of the genuine article has risen considerably, not merely in the United Kingdom, but in other countries where cement is produced in large quantities; and there is, therefore, a greater temptation for unscrupulous contractors to employ the low-priced, but vastly inferior, "natural cement" emanating from Belgium, and masquerading under the high-sounding but utterly false title of "Best Portland Cement."

OBITUARY NOTICE.

Julius Homan.

We regret to have to announce the death of Mr. Julius Homan, of Messrs. Homan and Rodgers, who died in the beginning of February, in his 91st year. He was one of the pioneers in steel and concrete construction and stated to be the inventor of compound girders, consisting of joists and plates, which he patented about 1868. He only recently retired from business—*i.e.*, 1912—and was well known for his indefatigable industry and great tact.



THE WATERFORD BRIDGE.

By ALBERT LAKEMAN.

The following article on the Waterford Bridge, which was opened last month, should be of considerable interest at the present time, when various municipalities and corporations are discussing the erection of new bridges or the enlarging of old ones, and in view of the fact that considerable doubt still seems to exist on the strength and safety of reinforced concrete bridges as compared with those constructed of other materials.—ED.

This is an interesting example of reinforced concrete work, as it forms the most important bridge constructed with this material in the United Kingdom, and it is estimated that a considerable saving was effected by the adoption of the present scheme as compared with the steel bridge at one time contemplated.

The old bridge which crossed the River Suir was constructed of timber, and as the new bridge was to be constructed in the same position it became necessary to form a temporary timber structure for the conduct of the traffic across the river during the period of reconstruction. This temporary bridge is just over 700 ft. long, and it has a width of 28 ft. between the parapets, thus giving a 20 ft. roadway and an 8 ft. footpath, while an opening portion 40 ft. clear is provided for the passage of vessels. The whole of the work of the temporary bridge was carried out in about four and a half months, and this must be considered a very creditable performance when the size of the structure and the great length of the piles are taken into account. Some of the piles were no less than 66 ft. long, and the difficulty of pitching these in deep water with a fast current running was considerable. The vertical piles were driven in sets of three by the main piling engine, and the triple pile driver was capable of being worked with a cantilever projection of 25 ft. beyond the support formed by the last completed trestle of the temporary bridge, and this allowed the gantry to be almost continuously moved forward. The raking piles on either side were driven by a single pile driver, which moved forward on rails behind the gantry, and which was swung round to work on either side as required. Upon the completion of the temporary bridge the old structure was closed to traffic and demolition was commenced by the contractors. It is interesting to note that the old piles when extracted were found to be pointed, and had only penetrated the river bed from 4 ft. to 8 ft., the latter being the maximum, while the piles in the new reinforced concrete bridge are driven down to a depth of at least 20 ft. below the river bed to the solid rock, and the cylinder piers are sunk to a depth varying from 6 ft. to 10 ft.

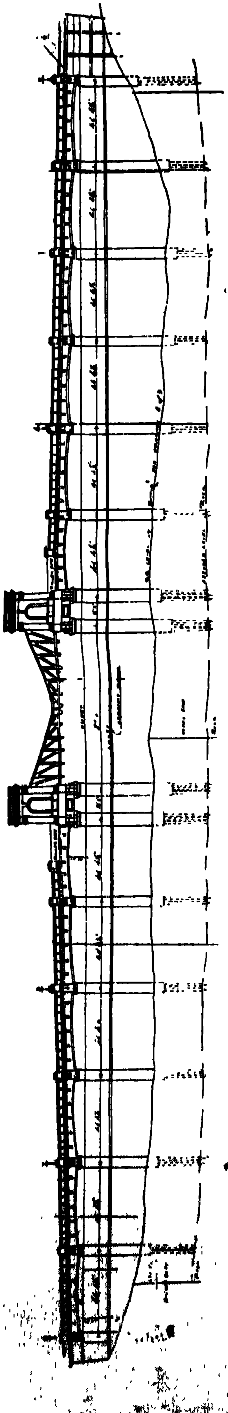


Fig. 1. Elevation of New Bridge.

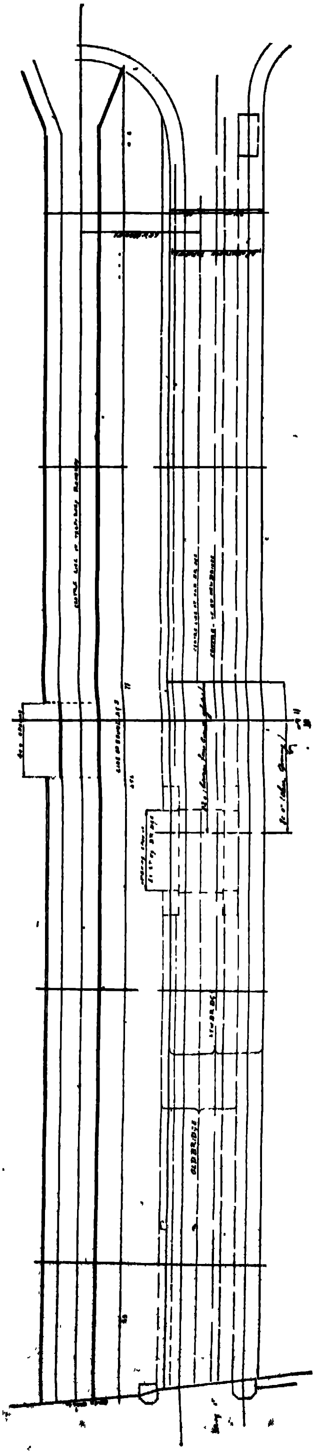


Fig. 2. Plan of Temporary and New Bridges.

THE WATERFORD BRIDGES.

The new reinforced concrete bridge is constructed on the Hennebique system in accordance with drawings and specification prepared by Mr. J. S. E. de Vesian, M.Inst.C.E., on behalf of Messrs. L. G. Mouchel and Partners, Ltd., of Westminster, while the engineer to the Bridge Committee is Mr. A. M. Burden, M.Inst.C.E., the County Engineer of Kilkenny. The method of preparing the work for the bridge is worthy of notice, as the contractors established a large manufactory close to the site and employed local labour for the preparation of the constructional members, the cement and steel only being brought to the works; thus the execution of the scheme gave much benefit to the population of Waterford. The works were established about half a mile from the site of the bridge on the upstream side on the bank of the river, and the transit of the various members when completed was there-

fore a comparatively simple matter. A large platform was built for the moulding of the reinforced concrete piles, and this was executed by forming rough concrete walls 12 in. thick at 4 ft. centres, upon which wooden plates were placed to carry the 9 in. by 3 in. grooved and tongued planks, constituting a perfectly level bed for the lower surface of the piles. The piles are 16 in. square, and the shuttering for the sides was made of two 8-in. by 2-in. boards placed on their edges and super-imposed with 7 in. by 1 in. cleats to connect same together. The shuttering was held in the vertical position by means of folding

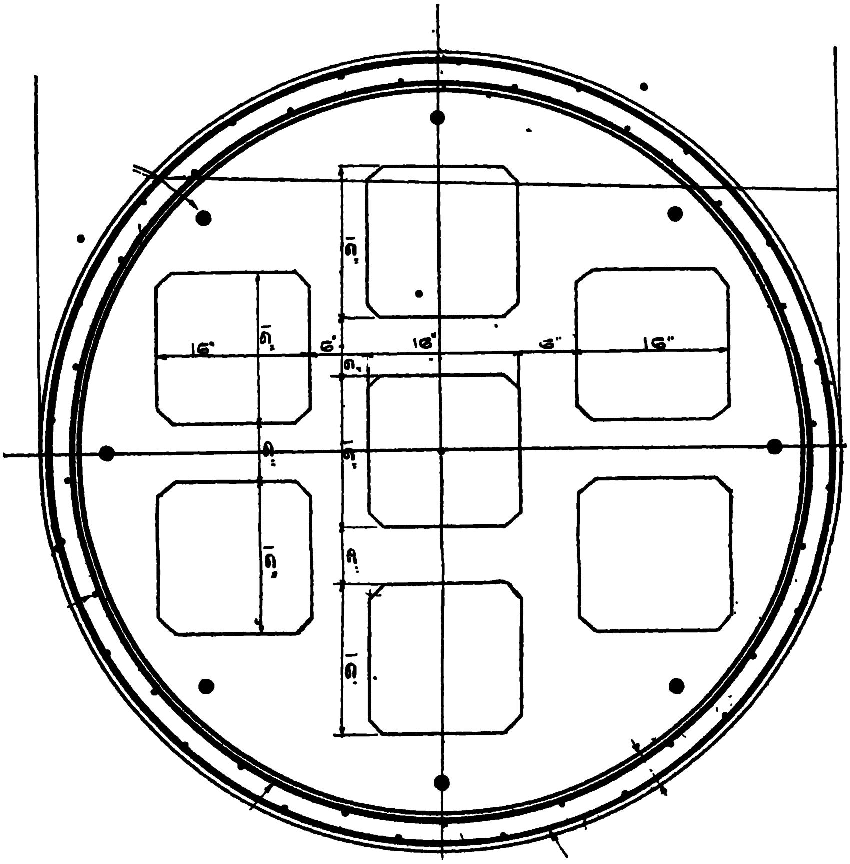


Fig. 3. Plan of Cyclinder Pier.
THE WATERFORD BRIDGE.

wedges at the bottom and distance pieces 5 in. long at the top. The total number of piles required for the work was 217, and these varied in length from 45 ft. to 65 ft., the consequence being that a considerable area was required for the moulding platform. In order to avoid a platform of excessive size the piles were moulded in three tiers, with 1 in. boarding placed between the first and second and second and third tiers. All the piles were made in about ten weeks, and each one was clearly numbered at the end to facilitate its transport to the required position in the work. When the piles were completed the process of moulding the pier cyclinders was commenced, and these

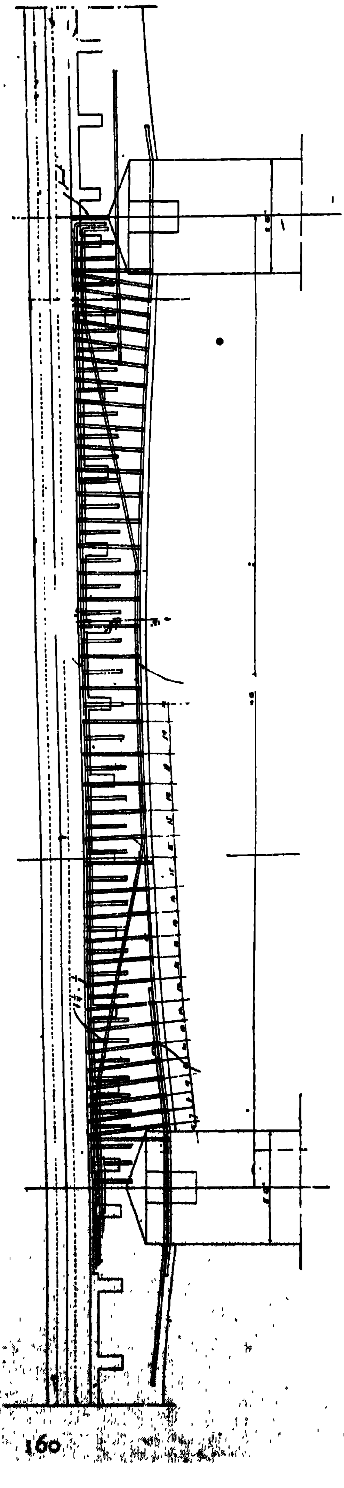


Fig. 4. Elevation of Centre Main Girder.

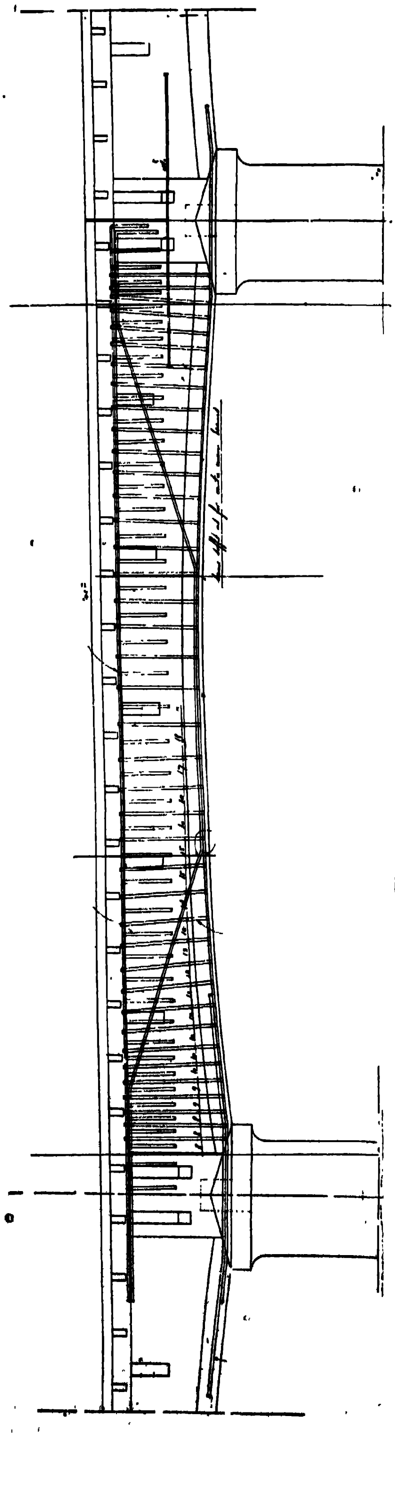


Fig. 4a. Elevation of Outside Main Girder.
THE WATERFORD BRIDGE.

were made in lengths of 6 ft., 9 ft., and 12 ft.; two sizes being required, one of which has a diameter of 5 ft. 6 in. and one of 7 ft., the thickness of the shell being 4 in. only and well reinforced with longitudinal and circumferential rods. This reinforcement was firstly built up in the form of a cage, and then lowered by means of a crane into the bottom ring of the timber mould, which consisted of a core formed of two semi-circular cradles fitted together with a separate outer case, also in two halves, which was arranged to give an annular space of 4 in. between the inner core and the outer form. The cores and shells were made in lengths of 3 ft., and consequently two or more lengths were

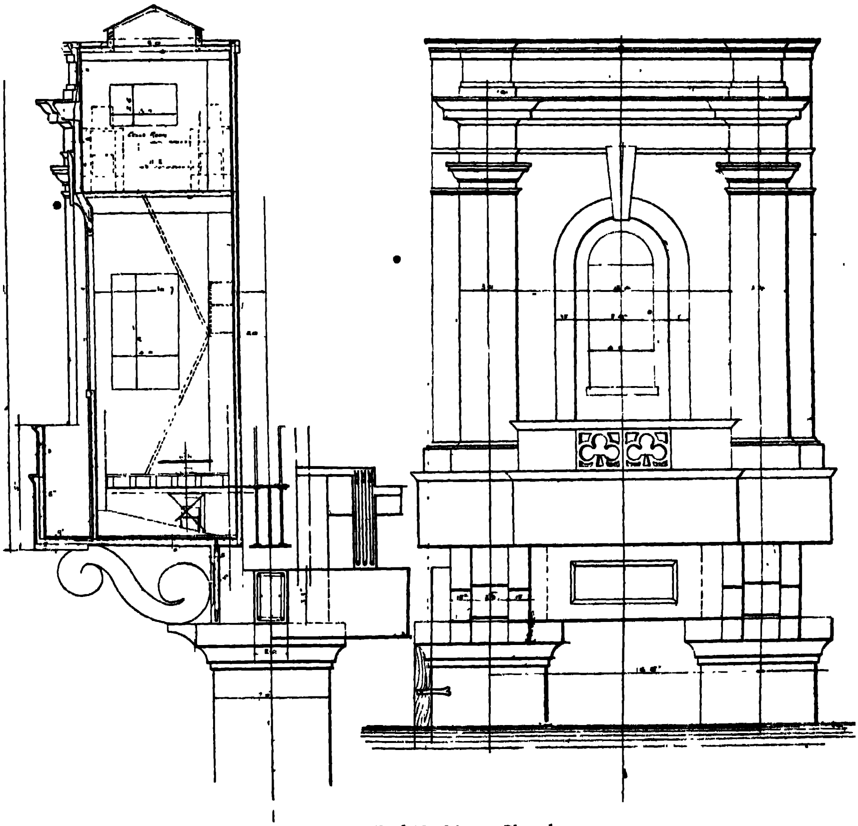


Fig. 5. Detail of Machinery Chamber.
THE WATERFORD BRIDGE.

used on the top of one another to give the required length to the cylinder. The power for the concrete mixer and other plant was supplied by a gas engine of 18½ h.p., and the slinging of the various materials was accomplished with a 10-ton steam derrick crane mounted on movable bogies.

When the work to the new bridge was commenced the various moulded members were slung into barges and transported to the site without any delay, and the execution proceeded very rapidly. The drawings illustrated in *Figs.* 1 and 2 give the general plan and elevation of the reinforced concrete work, and it will be seen that an opening portion 80 ft. wide is provided at

the centre for navigation purposes, and on either side of this opening portion the bridge is divided up into six equal bays by the river piers, which are spaced at 46-ft. 4½-in. centres. The total size of the bridge is 700 ft. by 48 ft. between

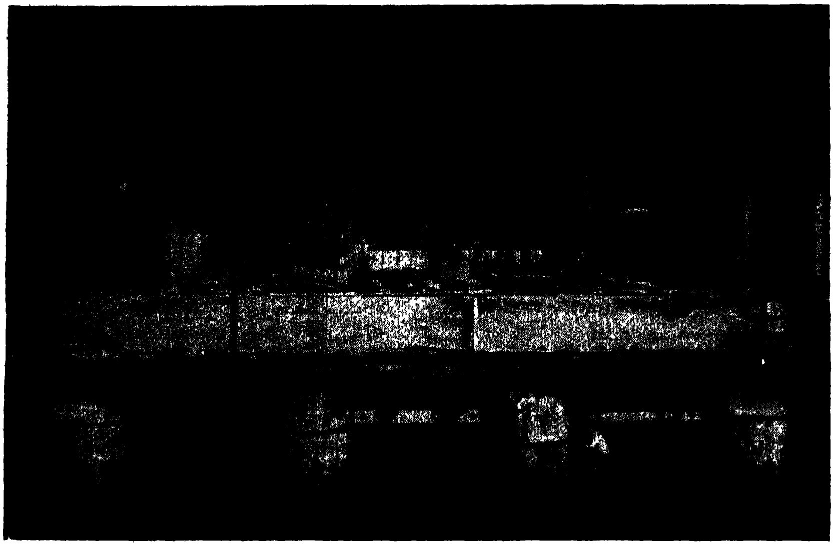


Fig. 6. Shuttering for Beams.

Fig. 7. Reinforcement to Cylinder Piers.
THE WATERFORD BRIDGE.

the parapets, giving a 32-ft. roadway and two 8-ft. footpaths. The piers are placed in rows of four across the width of the bridge, and these carry the four lines of main girders, which occur in each bay on either side of the opening

portion. The piers were formed by driving the 16-in. sq. reinforced piles in groups down to the solid rock, which was encountered at the average depth of 30 ft. below the bed of the river, and the cyclinder rings were then placed over these and lowered to the river bed, which had previously been dredged by

Fig 8. Beam Reinforcement in position.

Fig. 9. General View of Work in progress.
The Waterford Bridge.

means of a grab to allow the cyclinder to penetrate the required distance; the bottom ring having also a cutting edge to assist in the sinking. When the bottom ring had been lowered it was carefully levelled and wedged in position by a diver, and the successive sections were lowered and connected by means

of socketed joints, which were formed in the casting of the various parts. A plan of one of these cyclinder piers is illustrated in *Fig.* 3, when it will be seen that seven piles are grouped inside the cylinder, the outside diameter of the latter being 7 ft. and the thickness 4 in. This size was employed for the piers on either side of the navigation opening, of which there were sixteen altogether, the remainder of the piers containing three piles only and having an outside diameter of 5 ft. 6 in. The depositing of the cyclinder rings continued until the level of the low water bracing was nearly reached, and the interior of the pier was then filled in solid with concrete, which was delivered through a 12 in. diameter pipe. The bracing members are arranged in pairs, and they are made 36 in. deep and 18 in. wide, being moulded in advance, with the longitudinal reinforcement left protruding for carrying into the concrete filling of the cyclinders, where it was securely anchored. The high water bracing consists of similar members, the depth, however, being 30 in.

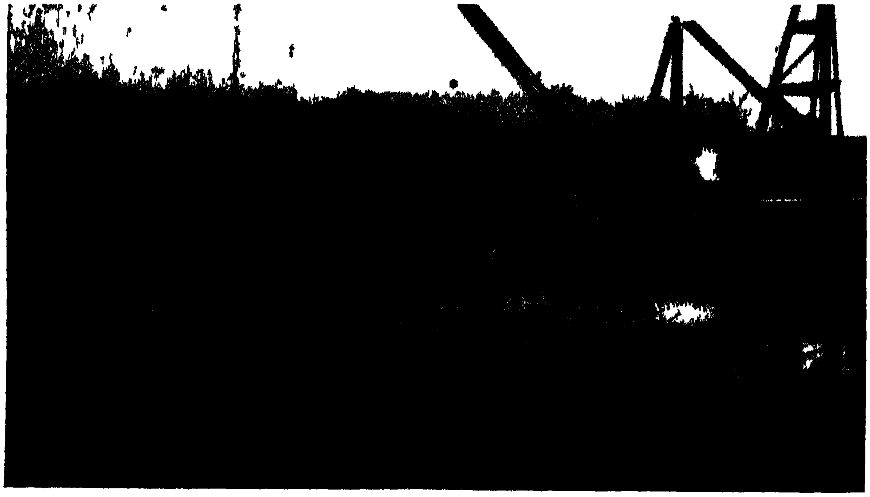


Fig. 10. View showing Bracing to Cyclinder Piers.
THE WATERFORD BRIDGE

only, while the main girders also obviously assist in the bracing. The cyclinders above the pile heads are continued as columns reinforced with seven lines of vertical reinforcement tied with transverse links spaced 12 in. apart, and a finish is formed with circular moulded capitals, which were cast in the contractors' yard.

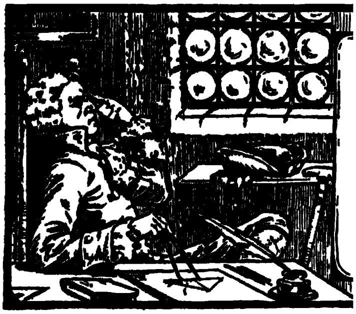
The main beams carrying the roadway have a span equal to the distance apart of the columns—viz., 46 ft. 4½ in.—and they are of two types, as illustrated in *Figs.* 4 and 4*a*. The outside beams are 5 ft. 6 in. deep and 16 in. wide, well reinforced, as shown in the drawings, while the two inside girders, which are coincident with the lines of the inside piers, are 4 ft. 2 in. deep and 16 in. wide. The centering for the moulding of these beams was carried by steel joists packed up by timber from the low water level bracing beams. The transverse beams are placed at 3 ft. 8½ in. apart centre to centre, and these are 14 in. deep and 7 in. wide, exclusive of the decking slab, which is 5½ in.

thick. The footpaths are carried by the outer main beams, and also by the alternate transverse beams being cantilevered out, as the footpaths project beyond the outer face of the former, and, in fact, the inner edge of the footpath is coincident with the inner face of these beams. The machinery for the manipulation of the opening portion is accommodated in four machinery chambers constructed in reinforced concrete at each corner of the opening, as shown in *Fig*. 5. The outer walls of these are only 4 in. thick, and two contain an upper floor for the storage batteries. The new bridge at the north end is connected to the new reinforced concrete viaduct, which was constructed a few years ago in front of the Great Southern and Western Railway, and at the south end the approach is joined up to the existing quay wall, which was not disturbed. The parapet is very effectively designed, as will be seen in the photograph of the finished work, illustrated in the frontispiece, and the pedestals occurring over the columns are bold and appropriate. The bridge is protected at the navigation opening by dolphins constructed of timber, and secured with piles driven at least 20 ft. into the river bed, while the cyclinder piers along each side of the opening are moulded with special provision for the attachment of timber fenders.

The gradient of the bridge roadway is approximately 1 in 31 on either side of the opening span. The structure is designed for vehicular traffic with axle loads up to 16 tons, but on completion it will be tested with the dead superload of 210 lb. per sq. ft. on the footpaths and two rolling loads of 32 tons each on the roadway. The specification demands that these loads shall be borne without causing any defect, without causing deflection greater than 1-600 of the span, and without causing appreciable permanent deformation.

The contractors for the work were Messrs. Kinnear, Moodie and Co., and the two rolling-lift spans were constructed by the Cleveland Bridge and Engineering Co.

Fig. 11. General View of Temporary Bridge.
The Waterford Bridge.



ECONOMICAL SLAB REINFORCEMENT.

By JOHN A DAVENPORT, M Sc, A M.Inst.C.E.

The following article should be of interest to those of our readers whose work includes the designing of concrete slabs.—ED.

IN the majority of cases reinforced concrete slabs are designed for uniformly distributed loads and for equal and continuous spans. In fact, the R.I.B.A. Report only considers definitely continuous slabs which are of equal spans and carry uniformly distributed loads, and recommends that, for such conditions, the bending moments at the centre of the span and immediately over the supports shall be taken as $\pm \frac{wl^2}{12}$; this in order to allow for any settlement of the supports. Thus the moments of resistance of the slab sections at the centre of the span and over the supports must be equal in magnitude, and as the thickness is the same throughout, it follows that the area of steel at each of these points will be the same.

It is not the object of this article to discuss what ratio the area of the steel to the area of the concrete should be for maximum economy; but, assuming that this be known, it is proposed to deal with the most economical method of arranging the bars. The complete design involves the calculation of slab thickness, the calculation of the area of steel in a certain width of slab, and the arrangement of the reinforcement as bars of a certain section and length spaced at definite intervals. The choice of section, size, and spacing of bars is a very simple matter and requires no further notice, but the determination of the lengths of the bars provides a means of making the design economical or otherwise In deciding upon the lengths of the bars the following points should always be considered :—

1. The reinforcement should be near the bottom surface in the middle section of the span.
2. The reinforcement should be near the top surface in the section over the supports.
3. The full area of the bars is required only in mid-span and immediately over the supports.
4. At intermediate points a smaller area will suffice.
5. At some intermediate point (the point of contraflexure) no tension reinforcement is required.
6. In all ordinary cases no shear reinforcement is necessary.

Points 1 and 2 follow from the fact that the whole of the tension is taken by the bars, which must therefore be placed near the tension surfaces of the slab.

Points 3, 4 and 5 follow from the fact that the bending moment has numerically maximum values at only two points in the span, and is zero at the point of contraflexure.

Regarding point 6, the R.I.B.A. report states that shear reinforcement is not generally necessary in slabs. Apart from this official statement, however, it will be found that the shear force at the point of contraflexure, the only point at which there should be a break in the bars, is less than the maximum shear force which occurs at the support, and much less than the shear resistance of the concrete. The distance of the point of contraflexure from the support is taken by the writer as quarter the span, but provision is made for a fairly large deviation. Since the shear forces can be safely resisted by the concrete, it therefore follows that tension reinforcement only is required, and it is not necessary that the top bars shall be connected to the bottom bars.

The following method, of which two alternatives are given, has been used by the writer for the last three years, and has always proved efficient, economical, and convenient. It is applicable to bars of any section or size, so that it may safely be used for patent bars or commercial sections.

1st ALTERNATIVE.

All the bars, except those which lie at the underside of the slab in the end spans, are of length equal to half the span plus 2 or 3 in. at each end, bent up or down to provide anchorage. The bottom bars in the end spans have straight lengths equal to three-quarters of the span plus 2- or 3-in. bent ends. If the end of the slab be fixed in a wall chase or in any other manner, alternate bottom bars are bent up to the top, as shown later, to resist any tension which occurs in the top of the slab.

All the bars, top and bottom, are arranged symmetrically about the supports and centres of spans, so that the end of the straight length of a top bar is vertically over the corresponding end of a bottom bar. They are then staggered a distance equal to the nearest 3 in. to one-tenth the span, alternate bars going right and left, as seen when looking across and not along the bars, and this gives the final arrangement.

This results in the full area of the bars for lengths of 0·3 of the span over the supports and in mid-span, and one-half the area for lengths of 0·1 of span about the points which are distant quarter of the span from the supports. It also allows the point of contraflexure to deviate an amount equal to 0·1 of the span on either side of the quarter-point.

In the foregoing description the bars are first arranged symmetrically and then staggered, but it will be found in practice that they can be correctly staggered when first put in, provided the right workmen and foreman are on the job.

Taking as an example a continuous slab of 12-ft. span, the amount of staggering must be 1 ft. 3 in.; the length of the intermediate bars 6 ft. plus 6 in. for two bent ends; and the length of the end bars 9 ft. plus 6 in. for two bent ends.

The arrangement is shown in *Fig.* 1, in which the plan shows, to an exaggerated scale, alternate bars lettered *A* and *B*. The correct disposition of

the bars relatively to the supports is shown in the sections with bar *A* above and bar *B* below. The details of the bars are given in *Fig.* 2, in which *C* shows top and bottom bars for all parts except in the bottom of the end spans, *D* shows the bottom bars in the end span when the end is not fixed in any way, and *E* shows alternate bottom bars in the end span when the end is fixed. Notice that the total lengths of the bars *D* and *E* are the same.

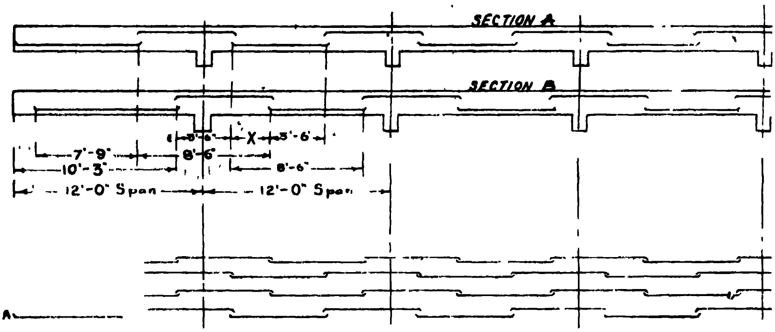


FIG. 1.

This arrangement results in the following disposition of the reinforcement, see *Fig.* 1.

Over the supports and in the intermediate spans the total area of metal required by the design occurs for a length of 3 ft. 6 in.

In the same parts not less than half this area occurs for a length of 8 ft. 6 in., so that there is tension reinforcement for a continuous length of nearly three-quarters the span.

In the end span the full area of metal occurs for a length of 7 ft. 9 in., and not less than half this area for a length of 10 ft. 3 in.

Further, the point of contraflexure may occur anywhere in the space *X*, which has a length of 2 ft. 6 in.

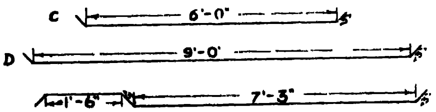


FIG. 2.

If the points 1 to 6, already noted, be compared with this arrangement it will be found that the reinforcement is disposed in the position and manner in which it can best resist all the tensile forces.

The advantages which result from this arrangement are :—

(*a*) All the bars, except those in the end spans, being of the same length means that the steel order is of the simplest form, and there is no risk of putting in, at any particular place, bars of the wrong length.

(*b*) As all the bars are straight, with short bent ends only, the work involved in bending is the easiest possible, and there is no risk of bends being put in the wrong place.

(*c*) As all the bars are comparatively short they are easy to handle, and there is no risk of accidental bends or kinks.

(*d*) As top and bottom bars are not connected together, no templates for holding up the bars are required.

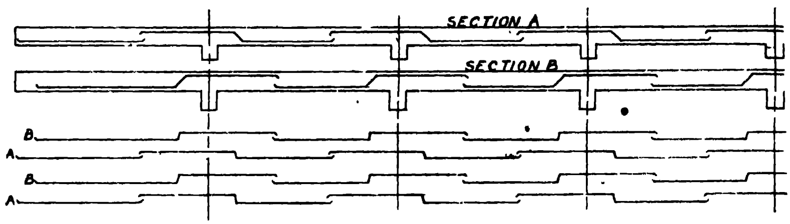
(*e*) The laying of bars and concrete can go on together, and no replacing is necessary as would be the case if the bars were laid first.

(*f*) The weight of steel can be calculated from a very simple formula.

(*g*) The cost of laying slabs is reduced to an absolute minimum.

The method of laying the slabs as used by the writer is as follows :—

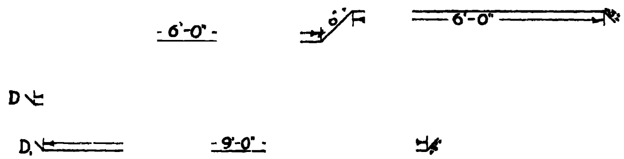
After the centering is ready, a sufficient number of bars are laid handy for the stretch to be concreted. The thickness of the cover is then laid and the



bottom bars immediately placed in the correct positions on the concrete. Further concrete is added till the surface has reached the level of the top bars; these are then laid and the slab completed.

2nd ALTERNATIVE.

The foregoing arrangement has had to be altered at times to meet the wishes of surveyors and architects, whose sole objection was to the discontinuity of the top and bottom bars. To overcome this objection adjacent top and bottom bars are connected by means of a 6" (or 4") diagonal, the resultant arrangement being the same as before, except for this. In order that the bars in any part may be connected to the bars in adjacent parts, alternate bottom bars are all connected to the corresponding top bars on the right, the intermediate bars being connected to the top bars on the left. Thus, apart from



bars in the end span, the total straight length of any bar is now twice what it was formerly. The advantages are the same as before, except that provision must be made to hold up the bars, and the longer length is not so convenient.

Figs. 3 and 4 show details for a slab of 12-ft. span corresponding to *Figs*. 1 and 2. In the end spans only alternate bottom bars are connected to the top bars, so that there are three lengths of bar instead of two as before. It will be noticed that in any set of bars, bottom or top, adjacent bars are connected right and left, so that the slab is tied from end to end in a width equal to twice the pitch of the bars.

The details of bottom bars for fixed end spans are not separately shown, being already given in *Fig*. 2.

Weight of Steel.—Taking first a bar running from end to end in the direction of length of the bar, the length of bent ends in any span will be $4 \times 3 = 12$ in., or 1 ft. For 2-in. bent ends this will be 8 in., but 3-in. ends are only considered now. The straight length in any span will be equal to the span, so that the total length of bar in one span will be 1 ft. longer than the span.

Now let L = total length of slab in feet, measured in the direction in which the bars run.

B = total breadth of slab in feet in the perpendicular direction.

n = total number of spans.

p = pitch of bars in inches.

Then the total length of one bar will be $L + n$ feet, and the number of bars in breadth B will be $\frac{12B}{p}$.

The total length of bar in the slab will be the product of these two quantities—*i.e.*, $\frac{12B}{p}(L + n)$ feet.

Now let A be the area of one bar, then, taking 3·4 lb. as the weight per foot run of 1 sq. in. of steel, the weight of the slab metal becomes

$$W = \frac{3{\cdot}4 \times 12 \times BA}{2240p}(L+n) \text{ tons.}$$

or

$$W = 0{\cdot}0182\frac{BA}{p}(L+n) \text{ tons.}$$

Taking a slab of 200 ft. length and 150 ft. breadth, divided into 20 spans of 10 ft. each, with ½-in. diameter bars at 6-in. centres—

$L = 200$

$n = 20$

$B = 150$

$p = 6$

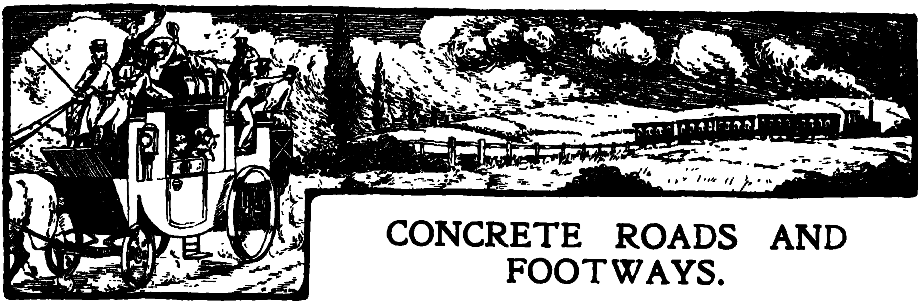
$A = 0{\cdot}196$

$$W = 0{\cdot}0182 \times \frac{150 \times 0{\cdot}196}{6}(200 + 20).$$

$$= \frac{0{\cdot}0182 \times 150 \times 0{\cdot}196 \times 220}{6}$$

$$= 19{\cdot}62 \text{ tons.}$$

The product 3·4 A gives the weight per foot run of the bar, and if this figure be preferred it may be used after slightly modifying the formula above.



CONCRETE ROADS AND FOOTWAYS.

By E. R. MATTHEWS, A.M.Inst.C.E., F.G.S.
Borough Engineer of Bridlington.

The question of the use of concrete for roads is receiving considerable attention in the United States, though it has only been used to a minor extent in this country.

We propose in subsequent issues to publish some further articles and papers on this subject, as it is one which merits a great deal more attention than is at present accorded to it.—ED.

WHILE footways constructed of concrete *in situ* have been formed in various parts of this country—and the author has had a good deal of experience in the construction of this class of footway, *Fig.* 1, for example, representing one of this type recently formed by him at Bridlington—nevertheless the use of this material in the formation of roads has, with a very few exceptions, not been adopted. The advent of the motor car upon our roads has necessitated the introduction of methods of construction which in the days of the horse-drawn vehicle would not have been thought of. A loosely-bound road surface is no longer of any use, for the rapid car has a tendency to tear out the metal even from a compact road surface. Concrete, therefore, is the latest material used in road construction, and it is the intention in this article to describe its use in America, for it is that country that has taken the lead in the use of this material. It is proposed to set out some of the advantages and disadvantages of using this material. *Figs.* 2 and 3 represent cross-sections through concrete roads and footways as recommended by the writer.

ADVANTAGES.

(1) Durability. —The chief advantage of a concrete road is that its life is greater than that of almost any other road, with the exception of perhaps granite and whinstone setts. The nature of the material of which the road is constructed is such that it increases in hardness and durability with age. This cannot be said of any other material.

Wood blocks become soft and often wear unevenly; stone setts, unless of granite or whinstone, vary in hardness, and fail in the same respect; granite macadam has to be renewed where there is heavy traffic on a road every three years or so, in some cases oftener; tar macadam can only stand light traffic, and then it has to be renewed every few years; but a concrete road will present as good a surface at the expiration of five years as on the day the road was completed.

Under these circumstances, and knowing the various purposes for which American engineers have used concrete, we are not surprised to find that at the present time there are in America under construction some hundreds of miles of

concrete roads, and that the New York State Commission of Highways are constructing about 200 miles of such roads, 50 miles of which are in the Rochester division. The California State Engineering Advisory Board also have 56 miles of concrete roads in hand.

(2) Uniform Wearing of Surface.— Unlike other methods of road construction, a concrete road wears uniformly, and not in holes as is the case with an ordinary macadam road; this is a very important matter.

(3) Cleanly Appearance.—A road of this class always presents a cleanly appearance, and can easily be cleansed by playing a hose upon it, or watering with water-carts and then sweeping well

(4) Maintenance.—It costs practically nothing to maintain a road of this class.

(5) Economical.—The cost of constructing such a road is no greater than that of a tar macadam road, as will be shown later.

FIG. 1. CONCRETE FOOTWAY, BRIDLINGTON.

DISADVANTAGES.

(1) Non-Elasticity.—The principal of these is that the extreme hardness and non-elasticity of the road make it somewhat injurious to horses using it, especially when the animals stand daily for hours upon the road, as in the case of a cab horse.

(2) Inclined to be slippery.—Unless the greatest care is taken a road of this class in certain weather will become slippery. The surface of the concrete should be cut up into V-shaped grooves about ½ in. deep and ½ in. wide, so as to give horses a better foothold. A road of this type should not be constructed where there is a considerable longitudinal gradient.

(3) Difficulty in Opening Out.—This is a serious objection, as the opening out of our town streets is almost a daily occurrence.

This objection might be overcome to a large extent by the construction

under the centre of the road of a reinforced concrete subway, which would accommodate gas and water mains, sewers, electric cables, telephone wires, etc., or these might all be laid under the footways, and the latter not be of concrete, but flagged or of asphalte; the disadvantage of this course is that the mains would have to be repeated on both sides of the road to really be of any benefit.

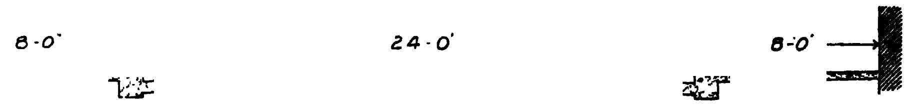


FIG. 2.—

(4) Somewhat Noisy.—The noise is reduced by the tarring of the surface, which should be repeated every other year or every third year if there is a good deal of traffic on the road. The tarring will cost about $1\frac{3}{4}$d. per sup. yd.

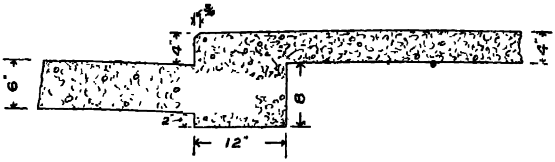


FIG. 2A.

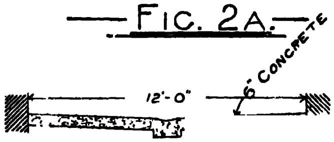


FIG. 3.

MATERIALS AND METHOD OF CONSTRUCTION RECOMMENDED BY THE AUTHOR.

Concrete Road: Proportions.—The concrete used should be in the proportions of 5 parts gravel or broken granite varying from $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. in size, 1 part coarse sand, and 1 part of Portland cement. A fairly wet mixture should be used.

Thickness of Concrete.—A thickness of concrete of 6 in. will be ample; it should not, however, be of less thickness.

Expansion Joints.—These should be inserted every 30 ft. The author on one occasion when forming a wide concrete footway omitted these, but found as a result that cracks appeared about every 30 ft.; he therefore strongly recommends their insertion.

Hand Tamping.—The pavement should be finished by hand tamping until the mortar comes freely to the surface.

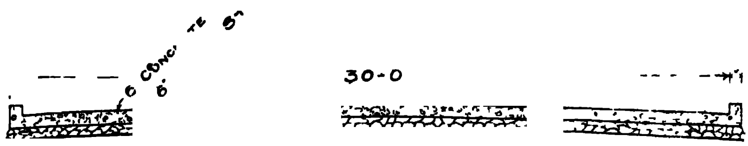
Tarred Surface.—It is advisable to tar the surface of the concrete (about $\frac{1}{4}$ gall. per sup. yd.), and to spread granite or limestone screenings, and to repeat this a year after.

Cost.—The New York concrete roads are costing \$9,000 to \$12,000 per mile, taking a 16-ft. road as a basis. The author estimates that such a road in this country would cost, including the tarring of surface, but independent of the cost of preparing the foundation, which should be formed in the same manner as for an ordinary macadam road, 3s. 6d. per sup. yd. only, which is a low figure for a permanent road.

Footways.—Footways, as shown in *Figs.* 1 and 2, formed of concrete

4 in. in thickness, have cost the author, with a brick-bat foundation, but no tarring of surface, 2s. 4d. per sup. yd. This is very little more than the cost of tar paving, while York or artificial stone flags have cost him 6s. 3d. per sup. yd. laid complete.

The footways should have a 6 to 1 concrete base with a 2-in. wearing surface of 1 : 1 cement and sand, and should be cut up into blocks, say, to imitate flags, or be pitted with a tooth roller. They should be brought up to a true face by means of a trowel.



— FIG 4

Kerb.—The author has usually formed this of the same material as the footways, but 12 in. by 8 in., and it has cost him about 3s. per lin. yd. The edge should have a ¾-in. chamfer as shown in *Fig.* 2a.

AMERICAN EXAMPLE OF CONCRETE ROAD.

A good example of a concrete road constructed recently in America is shown in *Fig* 4, which represents a road of this class just completed at Norwood, Ohio. It may be briefly described as follows:—

The concrete consisted of a 1 : 2½ : 5 mixture- sand and crushed stone—in the writer's opinion it should not have been a weaker mixture than 6 to 1. Expansion joints (½ in.) were placed transversely every 30 ft., and along each channel, and filled in with rubber asphalte.

The crushed stone used varied from ¾ in. to 2 in. in size, the sub-foundation consisting of cinders; the concrete was mixed by a Milwaukee mixer, and laid to a thickness of 6 inches, and the cost of constructing this concrete road worked out at $1.20 per sup. yd. Transverse expansion joints ¾ in. in width and filled in with pitch were inserted at Atchison, Kansas, where 9,500 sup. yd. of concrete roadway were laid last year.

This road cost $1.07 per sup. yd. The finished surface was covered with sand and kept wet for several days.

Reinforcement.—At Detroit the concrete was reinforced by the insertion of ⅜-in. round steel bars placed longitudinally and transversely at 2 ft. centres and within 1½ inches of the upper surface of the concrete. Other reinforcement was inserted on the underside of the concrete, and this consisted of ¼-in. steel bars laid at 4-ft. centres longitudinally and transversely; the top and bottom reinforcement was connected by means of clamps. The author does not see the need of inserting this light reinforcement, which adds to the cost, although it, of course, considerably increases the strength of the pavement, and, what is more important, it prevents longitudinal cracks occurring a year or two after the pavement has been laid.

The top layer of concrete at Detroit consisted of 1 : 1 : 3, the bottom layer of 1 : 3 : 6. Expansion joints were inserted every 30 ft. longitudinally.

Size of Aggregate.—While this at Norwood consisted of stones varying in size from ¾ in. to 2 in., the author recommends a smaller aggregate, say ½ in. to 1½ in. in size.

In a paper on "Concrete Roads" read by Mr. A. N. Johnson at the American Road Congress in October last, he advocates the practice of using aggregate of not more than 1 in. in its largest dimension, and the insertion of expansion joints every 40 ft. to 50 ft.

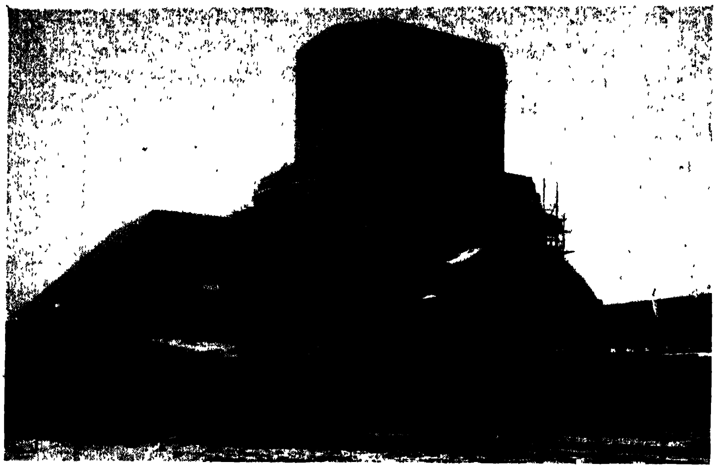
Concrete in one-course.—Professor F. P. Spalding, in his recently published "Roads and Pavements," advocates the placing of expansion joints every 50 ft., and at right angles to the kerb line, and suggests that they be at least 1 in. wide, and filled with a soft-wood strip of the same depth as the concrete. He recommends a one-course method in preference to the two-course in placing the concrete, so as to avoid a plane of weakness occurring between the two courses; and the author concurs in this suggestion.

Mr. Johnson's estimated cost of a road similar to that suggested by the author, and shown in *Fig.* 3, is $1.00 per sq. yd.

GENERAL.

There are many patented methods of concrete pavement construction in vogue in America; these include the Blome Company's Granitoid Blocking method, the Hassam Pavement, and Dolarway Pavement. It is not the intention of the author to describe these, but to conclude by saying that in his opinion concrete will be used a good deal in this country in the future in the construction of roads, especially in busy town streets and in narrow back roads.

THE INTERNATIONAL BUILDING EXHIBITION AT LEIPZIG IN THE MAKING.



By PH. RAUER, C.E.

In presenting the following article it is desired to draw special attention to this Exhibition, with a view to interesting all those concerned in this country, and it is hoped that at this Exhibition, which is International in its character, England may be well and adequately represented in the various sections. The Exhibition is to be opened in May and lasts until October.—ED.

THE epoch-making success which has attended the principle of exhibitions on special subjects has given a new and sudden trend to the ideas which have hitherto governed the erection of exhibitions. Such industries as are powerful enough to stand alone have followed this new impulse with surprising celerity. The industries of building and housing, the foremost and greatest industries of all, and those whose roots lie deepest in the soil of domestic life, have combined for the formation of a first general international review, the idea of which has now been realised in the impending Leipzig International Building Exhibition of 1913. It is characteristic of German thoroughness that the principle of specialisation has been fully realised in Germany, in hygienics by the Hygiene Exhibition, and now in architecture and housing through the coming Building Exhibition—that principle of specialisation which at once allows of a full representation of all matters in question and an efficient analysis of all pertinent subjects. A consistent solution of the problem of how to arrange a comprehensive exhibition of all matters pertaining to the departments of building and housing also necessitates a considerable increase in the area of ground to be occupied by the exhibition. No less than 475,000 sq. yds.—an area exceeding that of the Brussels Exhibition of 1910—is necessary in order to give a complete, though condensed, outline of the important building industry.

To the east of Leipzig, on the historical spot on which the great Battle of Leipzig was fought in 1813, the exhibition is built on hilly ground, from which elevated position the town of Leipzig, the seat of Germany's oldest university, can be overlooked. On the other side, looking towards the east, the eye is caught and held by the colossal stone monument to the Battle of Leipzig, erected to

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ANNOUNCEMENT.

THIS Journal—the pioneer journal of its kind in the British Empire—was founded in 1906 with the object of primarily meeting the demand for reliable technical and economic information regarding concrete, reinforced concrete, and constructional engineering generally.

The uses of concrete and steel are at present being accorded the closest possible attention throughout the world.

This journal continues to present a reliable digest of the world's latest information on concrete and constructional engineering as applicable to British and Colonial readers. It is intended to serve as a guide to what is being done at home and abroad, and will also serve as the medium for the expression of thought and opinion affected, presented by the ablest exponents on all questions connected with concrete and constructional engineering.

Originally issued as a bi-monthly journal, its reception has been so encouraging and its subscription list so influential that its development into a Monthly has followed almost as a matter of course.

SOME SUBJECTS ALREADY DEALT WITH:—

The Advance in the Concrete Age ...	LIEUT.-COL. J. WINN, R.E. (V. III. No. 1).
Reinforced Concrete in the States ...	CAPT. SEWELL, Corps of Engineers, U.S.A. (V. I. No. 2).
Reinforced Concrete in Italy ...	C. H. DI MONTEMERONE, Bologna (V. I. No. [illegible]).
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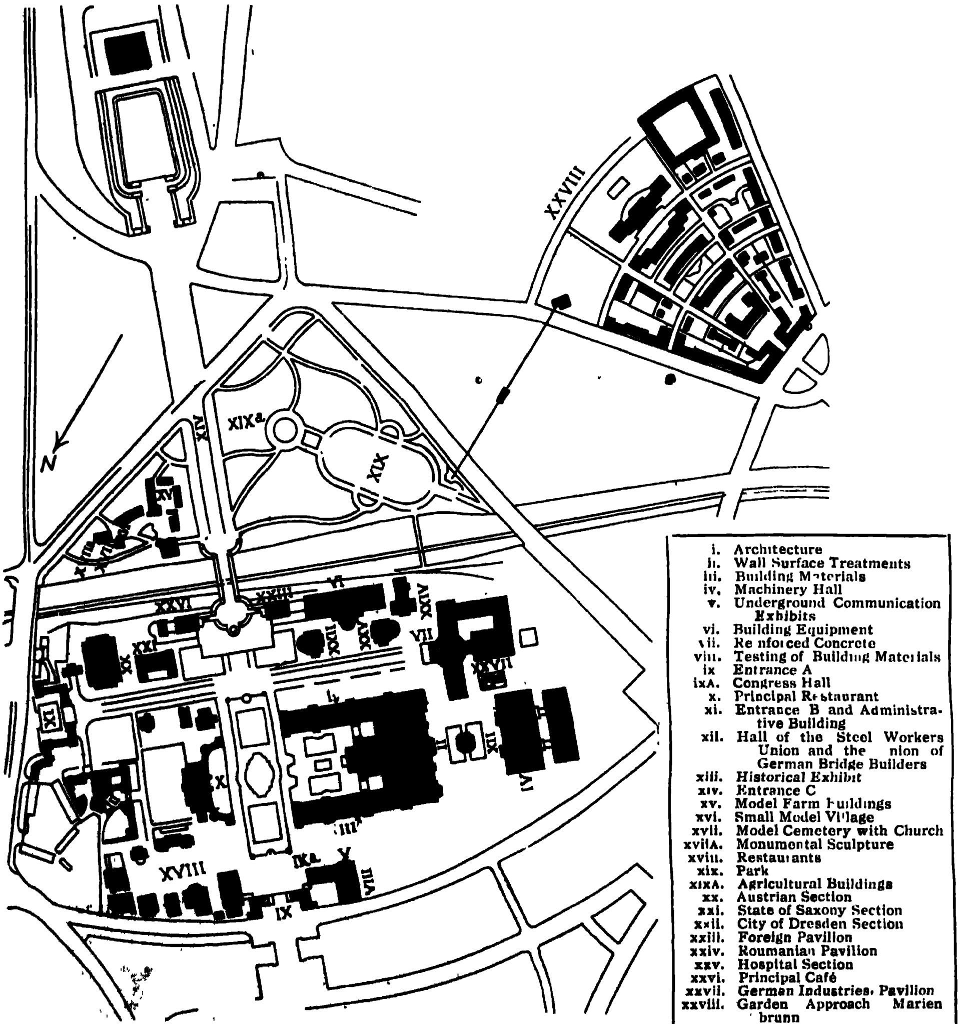
the memory of the heroes who shed their blood here a century ago. On the same soil on which the nations were then opposed to each other in deadly combat the friendly competition, which has but a single and common goal in view, will now take place.

"Leipzig in 1813."
THE INTERNATIONAL BUILDING EXHIBITION, LEIPZIG.

The exhibition grounds will be divided into two portions by a broad track of railway lines. The larger half, that lying nearest to the town, contains the chief and palatial exhibition buildings; the smaller half, that on the side of the

Monument, is laid out in park-like grounds, and contains the special agricultural exhibition, and a small village, complete with agricultural buildings, dwelling-houses, school, and church. A special site has also been selected for a recreation park.

In pleasant contrast to the want of clearness usually shown in other exhi-

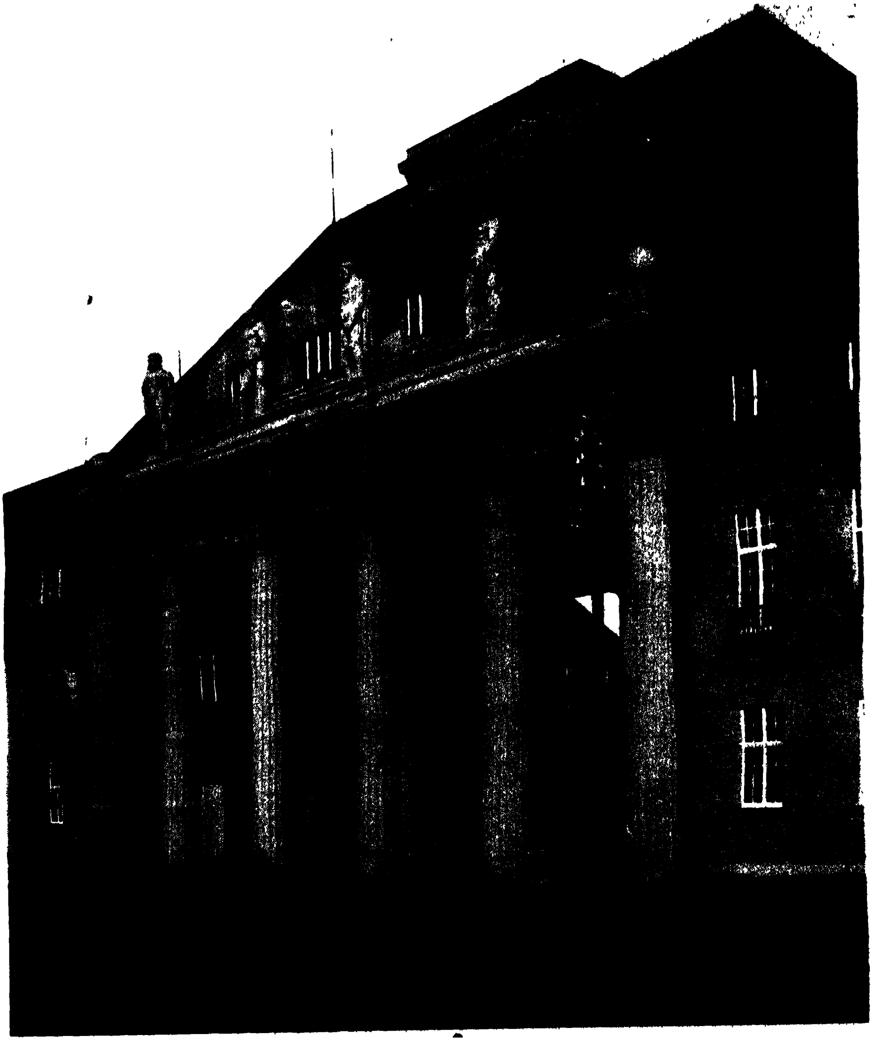


Plan of Exhibition Grounds.

THE INTERNATIONAL BUILDING EXHIBITION, LEIPZIG.

bitions in the arrangement of the chief buildings, the buildings in the Leipzig Exhibition are clearly and comprehensively arranged in groups according to their relations to each other. The general building design is the work of the Royal Government Surveyors, Weidenbach and Tschammer. The regular rise in the ground from the town of Leipzig to the crowning height on which the Monument of the Battle of Leipzig stands has been utilised with particular

ingenuity. From the main entrance, facing towards the town, a magnificent thoroughfare, 40 yds. in breadth, leads straight to the Monument, the axial arrangement of the buildings in this exhibition city being marked by a second lateral lime-tree avenue, 30 yds. broad and 500 yds. in length, crossing the main thoroughfare at right angles. The street crosses the railway cutting,



Administration Building.
THE INTERNATIONAL BUILDING EXHIBITION, LEIPZIG.

195 ft. broad, by means of a reinforced concrete girder-bridge, 8 ft. in breadth. The difference in the level of the ground here and on the farther side has been utilised for the formation of a terraced walk of considerable dimensions and of architectonic importance. At another point the railway cutting will be spanned

Old Leipzig.

by a second reinforced concrete bridge of technical interest, to be built on a new system of the editor of our contemporary, *Beton und Eisen,* Dr. von Emperger, of Vienna.

This erection exhibits a happy combination of ribbed cast-iron, natural steel on the Schroiff system, and latticed trusses without rivets. The use of cast-iron for the bearing of compression strain is technically a feature of peculiar interest in the structure. In order to afford a coherent picture of the present state of the entire building and housing industries, it has been decided to erect, apart from the industrial exhibitions and the exhibitions representative of different countries, a science and art exhibition, in which all subjects and objects of the exhibition are arranged, for the most part from a scientific point of view, and without regard to their origin. Here, owing to its carefully considered arrangement, valuable features of interest are offered to

Church in the Village.

THE INTERNATIONAL BUILDING EXHIBITION, LEIPZIG.

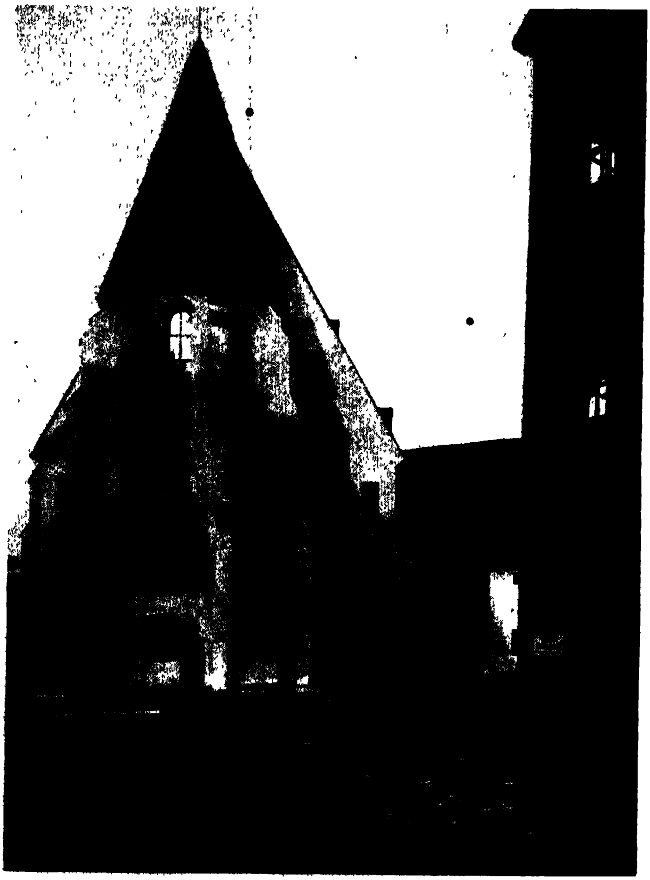
the view of the technical expert; while, on the other hand, great care has been taken to make the present stage of technical development comprehensible to the layman, to demonstrate the results of buildings in their relation to social, industrial and hygienic life, and so appeal to the intelligence of the masses, not only as regards general questions of technical practicability, but also in respect of the

Principal Entrance.
THE INTERNATIONAL BUILDING EXHIBITION, LEIPZIG.

value of the structures from a domestic and industrial point of view. Models, plans, and photographs alternate with statistical explanations and treatises on political economy in their relations to daily life.

The visitor to this technical and politico-economical exhibition will find here

a perfection and completeness of detail. Though unavoidable condensation has prevented historical retrospects in general from being taken, the visitor will yet find such short hints in all branches of technical science, as to the origin and consequences of technical events of the past, as are necessary to an understanding of the development in the art of engineering and architectural designing. From the examination of the work that precedes the erection of all structures we pass to the exhibits of the finished products of the art of engineering, of superstructure, and to the valuation of the single part in its relation to the whole construction. The settlement question and the social and hygienic relations of building and dwelling-house construction are also thoroughly gone into.



Thomas Church, Leipzig.
THE INTERNATIONAL BUILDING EXHIBITION, LEIPZIG.

A whole village owes its origin to the idea alone of representing the influence which architectural progress has had on agriculture.

The reinforced concrete hall may rank as the latest advance in the art of this form of construction. A reinforced concrete hall, 113 ft. high, with a cupola having a 97-ft. span and carried by 16 concrete pillars, is a further example of the applicability of this method of building, and finds its contrast and companion in an immense tower-like building of iron, crowned with a ball 19 ft. in diameter.

The exhibits illustrating the garden-city movement in the scientific department are represented by a garden city of 70 houses, which are not temporary, but built to last.

The block of chief buildings in the Exhibition consists of extensive industrial halls; the industrial section comprised in them covers 23,500 sq. yds., to which must be added the extensive open-air exhibitions. Here also specialisation is

consistently carried out. There are exhibitions for architectural art, interior decoration, building materials, building equipments, sport, hospital building, and two exhibition buildings for the machinery industry. Between the industrial halls stand the buildings representing foreign nations, and the pavilions of the various guilds, states, and authorities. In all the building and dwelling-house exhibitions all hygienic as well as domestic demands have been carefully attended to. Special exhibitions have been erected for two branches of hygienics, and have aroused the widest interest—the protection of the workman at the building site and the whole question of workmen's provision. The section for workmen's provision enjoys the services of a group of eminent physicians and the support of the trades unions and the National Bureau of Insurance. The General Commission of the Trades Unions of Germany will erect a building in a form and condition calculated to show the devices adopted to prevent accidents, not only by means of models, but also in a practical manner.

The town of Leipzig, within whose walls a large number of important congresses will take place this year, also contains many other objects of interest for the stranger.

Objects of interest will also be afforded for many visitors by the inauguration of the Monument of the Battle of Leipzig and the numerous features which will remind them of the historical days of a hundred years ago. The largest railway station in Europe, which is destined to cope with the enormous traffic, has also already opened its doors.

Nor have the peculiar historic recollections called up by the thought of the Battle of Leipzig in 1813 been neglected by the Exhibition. A whole town, with streets, squares, and alleys, represented as they were in 1813, has been erected with the name "Old Leipzig."

Front View of Administration Building.
THE INTERNATIONAL BUILDING EXHIBITION, LEIPSIG.

EXPERIMENTS on the ADHESION OF OLD AND NEW CONCRETE.

By HECTOR ST. GEORGE ROBINSON.

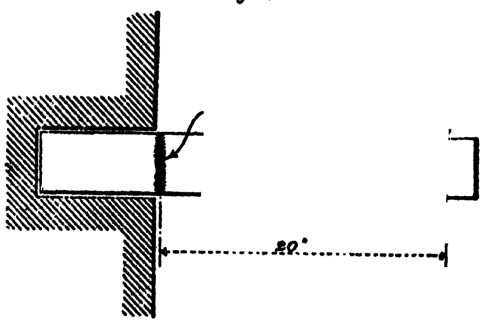
The following is a Paper which was published in the Proceedings of the Institution of Civil Engineers, and is now given here in full by the kind permission of the Institution.—ED.

IN examining cracks in plain and reinforced concrete structures, usually caused by shrinkage and thermal stresses, the author has observed the frequency with which such cracks occur in places where concreting has been stopped for some time and then resumed. The difficulty of obtaining good adhesion or bond between new concrete and concrete already set is generally recognised by engineers, and various methods of treating the old surface before laying the new concrete are in vogue.

With the object of terminating a dispute which arose in regard to the responsibility of a contractor for the efficiency of the joints in a fairly large reinforced concrete structure, the author carried out a series of experiments as to the relative efficiency of various methods of jointing concrete. The necessity of such tests was occasioned by the limited amount of experimental data available on the subject.

In view of the great difficulty experienced in obtaining reasonably uniform results when fairly large concrete specimens were tested in direct tension, it was decided to test prisms by cross-bending. The apparatus required to carry out this type of test is of an extremely simple description, and it was thus possible to make the tests under natural conditions in the field.

Fig. 1.



In connection with bending tests, it is important to keep in view the fact that the calculated stress in tension at the extreme edge of a bar of square or rectangular cross-section is much higher than the value obtained in direct tension. In the present case the tensional strength or modulus of rupture is used for comparative purposes only.

For the purpose of the experiments, concrete prisms 30 in. long and 4 in. square were made in timber moulds lined with zinc. The prisms were tested as simple cantilevers, being fixed at one end and loaded at the other as shown diagramatically in Fig. 1. The distance from the joint to the point of application of the load was 20 in..

and in arriving at the tensile stress at the joint the dead weight of the portion of the prism broken off was included. In testing, the prisms were reversed so that the top or tension side was the underside during moulding. The concrete was of uniform composition throughout and was made in the proportion of 2 cu. ft. of crushed Thames ballast, 1 cu. ft. of clean Thames sand to 45 lb. of Portland cement—practically a 4 : 2 : 1 mixture by volume. The ballast was mostly crushed flint pebbles, all passing a $\frac{3}{4}$-in. mesh sieve and being retained on a $\frac{1}{4}$-in. mesh sieve, the average percentage of voids being 34. The sand was screened from the normal Thames ballast, the grains being $\frac{1}{4}$-in. and less, and the voids in this case being 31·5 per cent. The cement was to the British Standard Specification and was bought in the open market. Its average tensile strength per square inch was as follows:—

Neat, at 1 day	243 lb.
,, ,, 7 days	625 ,,
,, ,, 2 months	768 ,,

It set initially in 1 hour 25 minutes, the final setting time being 4 hours 30 minutes. In mixing the concrete, 10 per cent. of water was used, based on the total weight of the dry materials. Five sets of prisms were made and the conditions as to mixing and storing were identical.

To arrive at a basis for comparison, a set of six prisms (reference " A ") were made without joints, these specimens being moulded and tested when twenty-eight days old. In the remainder, division boards of roughly-sawn spruce were fixed in the moulds 8 in. from one end and the first portion of the concrete was placed and well rammed. These short lengths were allowed to harden for seven days, after which the face against which the new concrete was to be placed was prepared and the prisms completed, care being taken to well ram the new material against the old face. The finished prisms were then allowed to harden for twenty-eight days, after which they were tested.

Four distinct types of joint were investigated. In series " B " the faces of the seven days' old concrete were merely washed and well wetted prior to the imposition of the new material. As these faces had been moulded against a somewhat rough soft-wood board they were fairly open and coarse, and the somewhat high efficiency obtained with these joints is due to this roughness. The faces in series " C " were roughened with a chisel, all the loose material cleaned away and the surface thoroughly wetted. In series " D " the faces were prepared first as in series " C," and were then washed over several times with a thick wash of semi-liquid neat cement grout, the new concrete being immediately applied. In the last series, " E," the faces were thoroughly cleansed with water and treated with hydrochloric acid. After the acid had

Calculated Tension at Extreme Edge, Lb. per Sq. In.

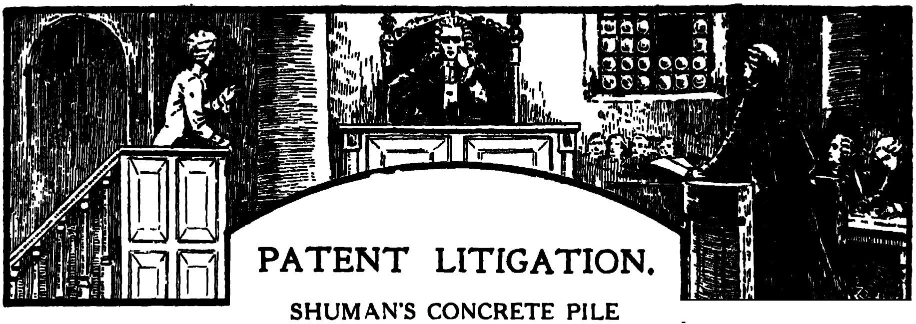
$f = \frac{M}{z}$, where f is the stress in lb. per sq. in., M the bending moment in inch-pounds, and z the modulus of section.

Series A.		Series B.		Series C.		Series D.		Series E.	
Test No.	So id Prisms.	Test No.	Face Wetted on'y.	Test No.	Face Roughened and Wetted.	Test No.	Face Roughened and Grouted.	Test No.	Face Treated with Acid.
A 1	302	B 1	140	C 1	194	D 1	325	E 1	300
A 2	362	B 2	78	C 2	170	D 2	—	E 2	248
A 3	289	B 3	130	C 3	205	D 3	272	E 3	260
A 4	—	B 4	110	C 4	142	D 4	280	E 4	201
A 5	340	B 5	—	C 5	165	D 5	248	E 5	340
A 6	352	B 6	172	C 6	234	D 6	—	E 6	271
Average	329	—	126	—	185	—	281·25	—	270
Efficiency	100 %	—	38·3 %	—	56·2 %	—	85·5 %	—	82 %

removed the cement to a sufficient depth to expose the aggregate and thus leave a very rough face, all traces of the acid were removed with stiff brushes and water and the new concrete was then applied.

The results of the tests are tabulated in the accompanying table. Prisms A4 and B5 were defective, while prisms D2 and D6 broke outside the joint, therefore these cases have not been included in the table. All the other specimens broke wholly or partly at the joints. The average efficiency of the various joints in the table is given in relation to the strength of the unjointed prisms.

While these tests are somewhat limited in scope, it is evident that there is a considerable difference in the strength of the various joints. The value of roughening and grouting is clearly apparent. The joints treated with acid show a high efficiency, but the trouble and care necessary for the successful use of acid, especially where an aggregate of a porous nature is used, is opposed to its adoption in actual practice.



PATENT LITIGATION.

SHUMAN'S CONCRETE PILE PATENT UPHELD.

The following is the report of some proceedings of general technical interest, heard at the Royal Courts of Justice, London. At the time of going to press an appeal has been entered.

THE case of Simplex Concrete Piles, Ltd., *v.* J. and W. Stewart* came on for hearing before Mr. Justice Neville on February 4th and 5th. The action was brought for infringement of Frank Shuman's Letters Patent No. 9025** A.D. 1904, of which the plaintiffs are the registered proprietors. The Specification had been twice amended. First, in view of J. Potter's Patent No. 1124 A.D. 1864, which describes a method of constructing piles by first sinking a tubular pile with a loose tip or point, filling the tube with artificial stone composition, and then withdrawing the tube, the supply of fresh composition being kept up as the tube was withdrawn. The tip was left in the ground and formed a foundation for the pile. The drawing shows a tip of the same diameter across the top as the tube. On this amendment the original second claim was cut out and a disclaimer inserted to restrict the first claim, which was of a broad nature. By the leave of the Court, a second amendment was made, by which the first claim was abandoned; and the original third claim is now the only one. With certain abbreviations, the Specification now stands as follows, the claim being given in full :—

The invention relates to that method of forming piles of concrete or cement which consists in first driving a preparatory pile into the ground and then withdrawing the said preparatory pile and filling the opening formed thereby with concrete or cement in a fluid or plastic condition which, when it becomes set, forms the permanent pile. The object is to fill the openings with concrete or cement in a better manner than heretofore and produce a better pile. In the accompanying drawing, *Fig.* 1 is a vertical section illustrating the method of forming the opening in the ground by means of a preparatory pile, and *Figs.* 2, 3 and 4 illustrate successive stages in the formation of the permanent pile.

The preparatory pile consists of a metal tube 1, provided at its top with a driving head 2, and at its bottom with a point or end-piece 3, which is detachable from the tube 1, and is, in the example illustrated, of greater diameter than the said tube, with the object that the said tube 1, shall not come into contact to any material extent with the walls of the opening formed by driving the preparatory pile, so that the said pile can be driven without the excessive friction which results from the contact of the earth with the sides of the pile, when the pile, as a whole, is cylindrical or of the same width throughout, or tapers from top to bottom, the improved pile being also capable of easy withdrawal, owing to the fact that the point or end-piece 3, remains at the bottom of the opening, and the tube 1 is free from any material contact with the walls of the opening above the said point or end-piece.

After the said preparatory pile has been driven to the proper depth, the concrete or cement is passed into its interior, and when a sufficient quantity has accumulated at the bottom of the tube above the point, the tube is withdrawn, either slowly and continuously or intermittently—a little at a time, and, during such withdrawal, the supply of concrete or cement to the interior of the tube is effected intermittently, so that the concrete or cement will escape into the opening above the point 3, as shown in *Figs.* 2, 3 and 4, until by the time the tube 1 is completely withdrawn, the opening will be filled with concrete or cement.

When the opening is formed in wet ground or beneath water, the concrete or cement is introduced into the tube or hollow stem at such a rate as to always maintain a head of concrete or cement at the bottom thereof so that water cannot gain access to

* Reported by DOUGLAS LEECHMAN, A.I.M.E., Barrister-at Law.
** Official indication of the two amendments.

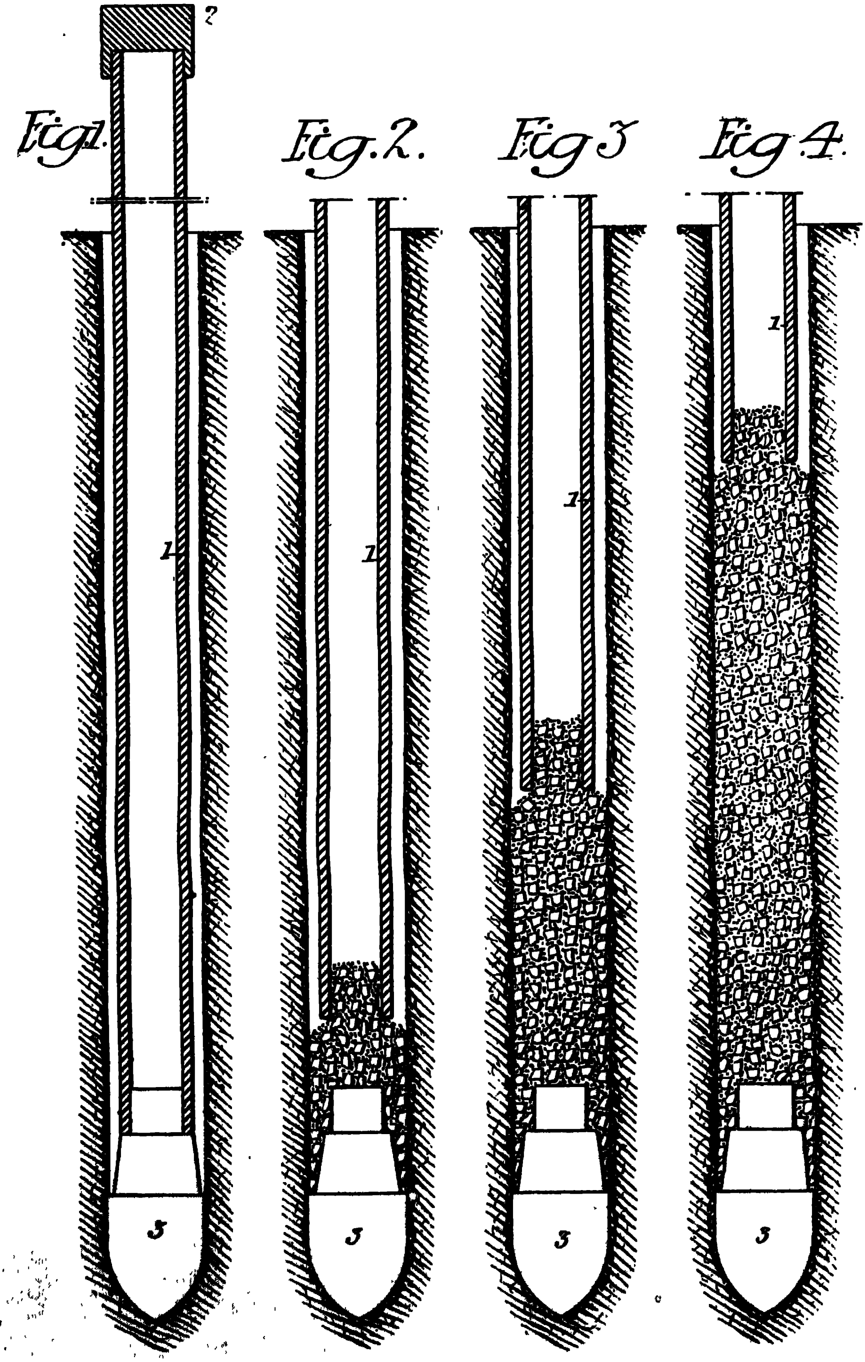


Fig. 1.
Fig. 2.
Fig. 3
Fig. 4.
2
1
3

the interior of the tube, but will be displaced upwardly as the concrete or cement escapes from the lower end of the tube and into the opening outside the tube.

By this means caving-in of the walls of the opening, when such opening is formed in unstable ground, is effectually prevented, and the concrete or cement pile, when it becomes set, is a homogeneous structure possessing the needed strength.

The point 3 can be made of any desired shape and of any material which will withstand the shock of driving, preference being given to a point of concrete which may, if desired, be sheathed with sheet metal, except at the top, or be internally reinforced to strengthen it, as the plastic concrete or cement of which the pile is composed will take a better hold upon such concrete point than upon a metal or other point not affording so good a holding surface.

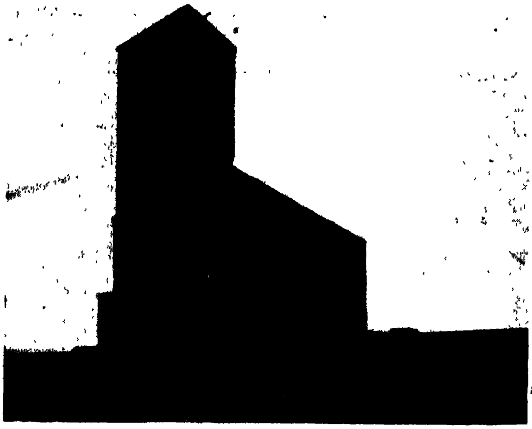
Although the invention is described in connection with a preparatory pile provided with a cap and a detachable point, the method of forming concrete or cement piles may be employed in connection with the use of any suitable hollow preparatory pile open at the bottom for the escape of the concrete or cement therefrom as the said preparatory pile is withdrawn, but is limited to cases in which the hole made by the preparatory pile is of larger diameter than that of the greater part of the tube or stem of the pile.

Claim,—The method of forming concrete, or cement (*sic*) piles, which consists in providing a hollow pile with an enlarged and detachable point or end-piece, of concrete or other material, or materials, sinking the said pile into the ground to form a hole larger than the pile stem, then slowly, or intermittently withdrawing the said pile without its said point or end-piece, and filling the hole above the said point or end piece with concrete, or cement during such withdrawal, and then permitting the concrete, or cement to set, substantially as hereinbefore explained.

The essential characteristic of the invention, therefore, is the making of the shoe of larger diameter than the tube; in practice it is made about 1 in. larger.

For a time the Defendants were licensees under the Patent, but now the Plaintiffs act as contractors themselves. In their defence Messrs. Stewart relied partly upon Potter's early patent and partly on a tubular well which had been sunk with a pointed bottom and perforated lower ends. In the course of the work a large tube had been driven down and gravel, etc., extruded from it to form a filtering material.

In the result, Mr. Justice Neville held that there was sufficient subject matter to support the patent, and that the Defendants had infringed. Accordingly he gave judgment for the Plaintiffs, granting them the usual relief, including an injunction against the infringement of the Letters Patent, damages and costs. By the consent of the Plaintiffs the injunction was suspended in respect of contracts already accepted by the Defendants provided notice of appeal was given within fourteen days.



CONCRETE GRAIN ELEVATORS IN CANADA.

By B. I. WELLER.

The Ninth Convention of the National Association of Cement Users took place in December last, and quite a number of interesting papers were again read, of which we reprint the following one in abstract form. Further papers will be printed in subsequent issues.—ED.

EARLY HISTORY OF GRAIN ELEVATORS.

ELEVATORS as a means of housing and handling grain did not make their appearance until the latter part of the last century. The first real elevator of which there is any record is the "cribbed" wood type, and there are still a good many of these houses in existence. This old type is interesting when it is considered that at one time an elevator of nearly four million bushels capacity was erected complete, and almost totally filled with grain, in a period of forty-four days. Of course, lumber was plentiful, and no expense was spared and no restrictions put on the builder except to gain time. As the price of lumber advanced, it became necessary to cast about for other kinds of material with which to build, the elevator operator and owner seeking for a material which would appreciably lower the insurance rate, which was very high on wood.

The first fire-resisting elevators were built of steel, practically on the same plan as the old wooden structures, which were rectangular in plan and had cribbed bins elevated on posts and usually arranged to suit unloading conditions. Up to this point all storage and handling devices were carried under one roof, but it was then demonstrated that all machinery for unloading, handling, and shipping could be more economically installed in separate buildings called the working house. This was accomplished by having two or more parallel tracks alongside of the house for unloading, thus shortening the house and necessarily making it more economical; a separate building for storage being erected having larger compartments than in the working house. At about this time there came into common use, in the construction of elevators, brick, tile, and concrete, which will be dealt with later.

CLASSIFICATION OF GRAIN ELEVATORS.

Grain elevators in general may be classified under the following heads: Terminal. Transfer, Country or Line Houses, Private or Hospital. Of the above-named classes the Terminal is by far the largest. This type of house is to a greater or less extent under the supervision of the Government, both as regards the classification of the different kinds of grain and also the weights of same.

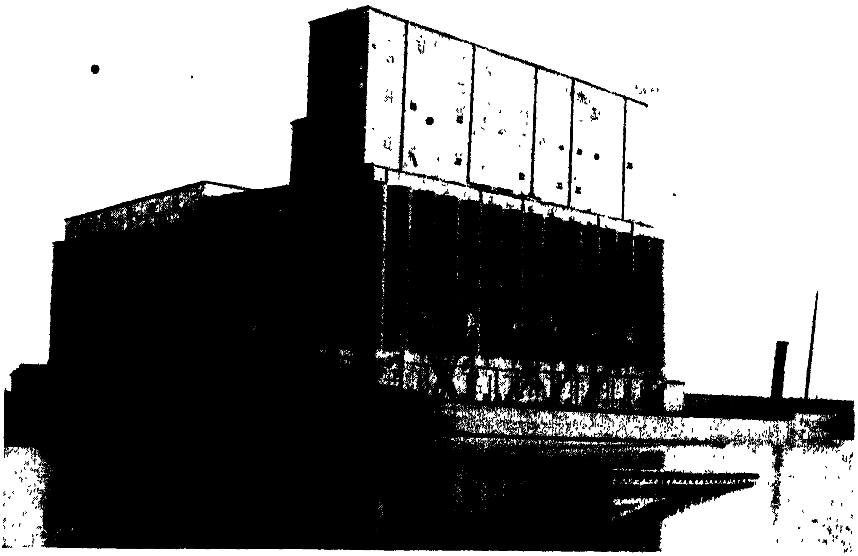
Terminal houses are so called because they are usually situated on a lake or ocean port and receive their grain either direct from the farmer or through their line or country houses.

When grain is received by a terminal house it is given a grade by the inspectors, and either stored awaiting future delivery or is shipped direct by boat or rail, usually the former. Part of this grain may have to go through different processes, such as bleaching, drying, or cleaning. The cleaning and drying when necessary, of certain portions of this grain, is generally absorbed by the operators of the house.

Terminal houses are usually controlled by grain firms, who also have their own line and country houses. These country houses vary in size from 10,000- to 50,000-bushel storage capacity, and are placed along railroads throughout the country where the grain is grown. These houses, after receiving the grain from the farmer, ship direct to their terminal house.

METHOD OF HANDLING GRAIN.

It may be interesting to give an idea of how much work can be done by some of the elevators which have lately been constructed. The Canadian Stewart Company



TERMINAL ELEVATOR, FORT WILLIAM, ONTARIO, FOR THE GRAND TRUNK PACIFIC RAILWAY.

recently constructed a reinforced concrete elevator for the Grand Trunk Pacific Railroad Company, at Fort William, Ontario. In the track-shed of this elevator there is room for spouting over the receiving pits, twenty cars at one time, and in a double shift of twenty hours it is possible to unload over 600 cars of grain. A boat which can carry a cargo of 400,000 bushels of wheat can be loaded at this elevator by means of five dock spouts in about three and a-half hours. This house is equipped with nineteen cleaning machines, each one able to clean as high as 3,000 bushels per hour, and in the dryer house it is possible to dry about 2,000 bushels per hour. There are also nineteen elevator legs in this house. Most of these legs have a capacity of elevating 18,000 bushels per hour each. There are ten 2,000-bushel hopper scales, and it is interesting to note that each hopper can be filled, weighed, and unloaded in a little less than three and a half-minutes. The total capacity of this house is a little less than three and three-quarter million bushels, of which the working house capacity is about three-quarters of a million bushels storage capacity.

In regard to power for these elevators, it may be said that, almost without exception, all up-to-date houses are now equipped with individual motors for the different

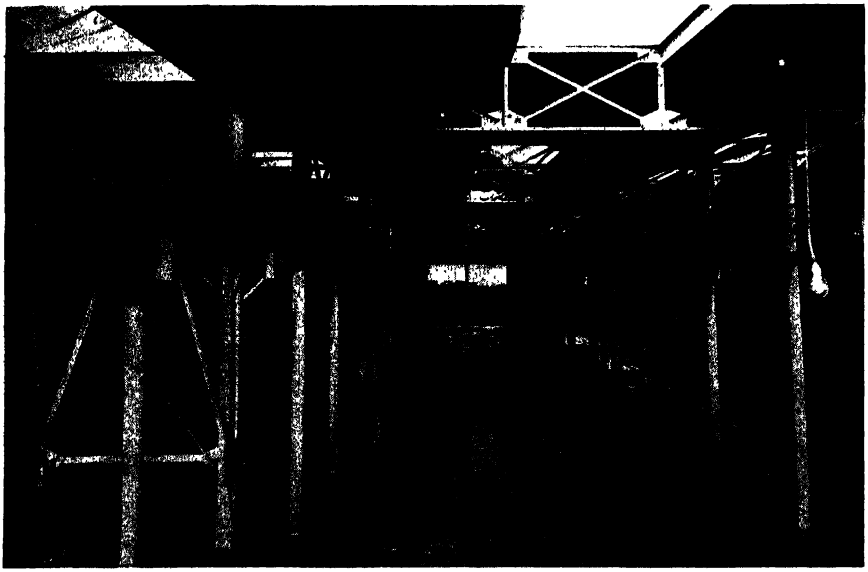
machines, conveyor belts, etc. This has been proven more satisfactory as to service and also is more economical.

Rubber belting of a high grade is used both for conveyors and elevator legs, and in transmission manilla rope is used, both gears and belting having become obsolete, the former principally on account of the noise and the latter on account of slippage.

In regard to marine towers, the above-mentioned firm recently erected for the Washburn-Crosby Company, of Buffalo, a tower which was cylindrical in form and 160 ft. in height. This tower was equipped with marine leg, which is by far the fastest on the great lakes, being able to unload a complete cargo of grain at an average speed of 22,000 bushels per hour. The tower, of course, also contains automatic scales, and delivers the grain direct to the company elevator by means of conveyor belt running through a tunnel.

MATERIALS USED IN CONSTRUCTION.

The different materials from which elevators have been built are as follows: Wood,



Interior View.
TERMINAL GRAIN ELEVATOR, FORT WILLIAM, ONTARIO.

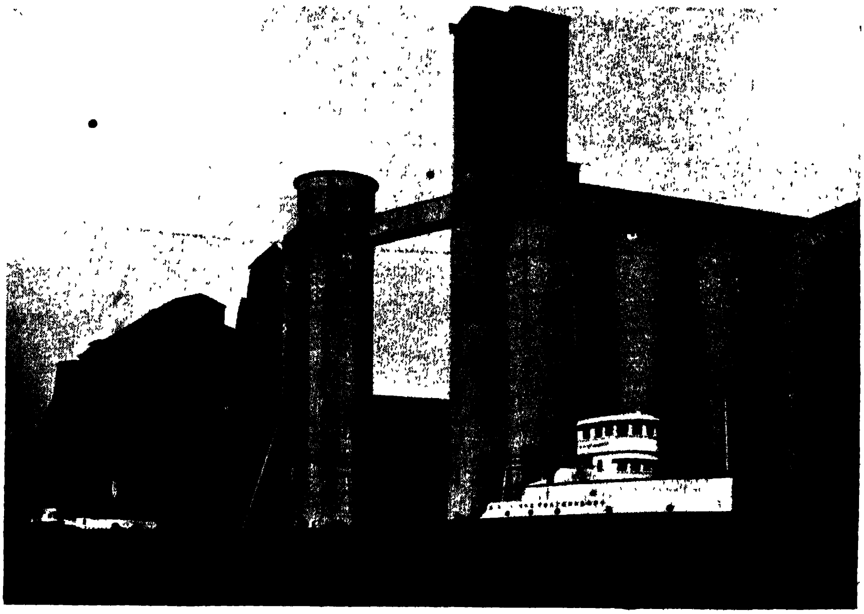
steel, brick, tile, and concrete. These have been named in the order in which they came into general use, and at the present time few elevators are built of any material save concrete. Wood was found to be very expensive when insurance rates were taken into consideration. Steel is a high conductor of heat, and there is on record an instance where four box cars, lying in a track-shed, caught fire, resulting in the wrecking of a steel house of over one-half million bushels capacity. The steel walls of the storage tanks were, of course, very thin, offering little resistance to fires due to the burning of adjacent buildings, and so much of the grain would be damaged due to excessive heat that steel has been found impracticable.

There have been a great many elevators constructed of brick, but it is usually too costly on account of the walls having to be made so thick in order to suit reinforcing conditions, etc.

Tile was used for a number of years, and even now and then elevators are built of this material. The main fault to be found with this material is that it is hard to ensure an absolutely waterproof job.

The first concrete elevator was built in 1902, and as soon as the tanks had been filled with grain several of them burst. This naturally retarded the use of concrete for two or three years. However, after one or two concrete elevators had been erected by well-known firms, the elevator owners regained confidence in this material. For some time concrete was used only in foundations and in the storage annexe, steel or wood being used throughout the working house. Later on storage bins in the working house and the columns supporting same were made of concrete, and only the cupola, which is that part of the elevator above the tanks, was built of steel.

It has been clearly demonstrated that there is no better material for protecting the grain than concrete, on account of its being a poor conductor of heat or cold, and, being denser and freer from porosity than either tile or brick, it has greater waterproof qualities.



TERMINAL ELEVATOR, FORT WILLIAM, ONTARIO, FOR THE GRAND TRUNK PACIFIC RAILWAY.

Another point in favour of concrete construction is the low cost, due to the fact that there is practically no skilled labour required in the construction of the modern elevator.

METHODS OF CONSTRUCTION.

The equipment for handling concrete in the modern elevator differs very little from the methods used in placing concrete in any other building, with the exception of the forms, in which great advancement has been made in the last few years, the forms for the foundation, of course, being stationary, but all forms above the foundations are movable. These forms are made of 2-in. plank, surfaced on one side and two edges, and the form over all is about 4 ft. 6 in. in height. After the foundation has been completed these forms are set over the whole area and filled with concrete in layers of about 8 in. thickness. The raising of these forms is accomplished by a series of jacks, in which there are from six to eight on each tank, or, if they are used on straight walls, they are placed about 5 or 6 ft. apart. These jacks are set in a yoke which is a framework of steel and is connected to the wooden forms. Through each jack there is a jacking rod about 1 in. in diameter running vertically. To operate the jacks a bar is placed in the socket, causing a screw to turn which, if turned to the right, lifts the forms, and if turned to the left, the jack itself climbs the jacking rod, while the forms

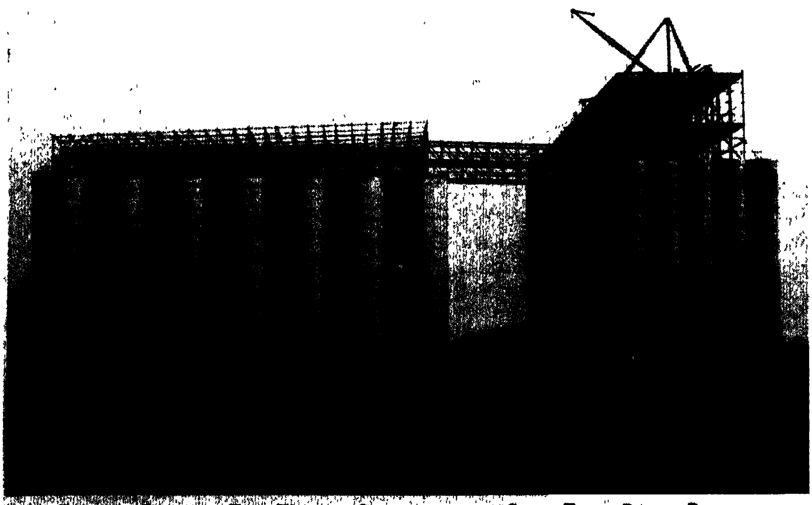
remain stationary, being supported by the two adjacent jacks. By reason of the rod passing through the jack, the load is applied concentrically, and leaves no tendency for the forms to bind. These jacking rods are placed directly on the top of each other, and no dismantling of the forms is required when additional rods are added. These yokes are connected by means of trusses, and these, in turn, support the temporary floor for the convenience of the working men and permit easier handling of material. This continual moving of forms does away with the horizontal rings and discolorations so often to be seen in the first concrete elevators. This type of form also has greatly reduced the cost over the stationary forms used originally or the primitive jacking system first adopted, which was accomplished by jacking from the ground all the way to the top of the elevator.

In the working house the girders, where required for floors, are poured simultaneously with the walls, the floor slab generally being put in later. This is done so as not to impede the progress of the wall forms. In reinforcing the tanks flat bars are used, being placed midway between the forms and at equal intervals, the difference in pressure below and above being taken care of by the size of the flat. The jacking rod on which the forms are raised is also part of the vertical reinforcing, and similar rods placed between the series of jacking rods form the balance of the vertical reinforcing. The tanks are always laid out in parallel rows. Contacts must be provided for, and this is generally arranged by a system of horizontal anchors and additional concrete in the interstices. This arrangement of bins leaves the space between the different tanks, which is called an interstice bin.

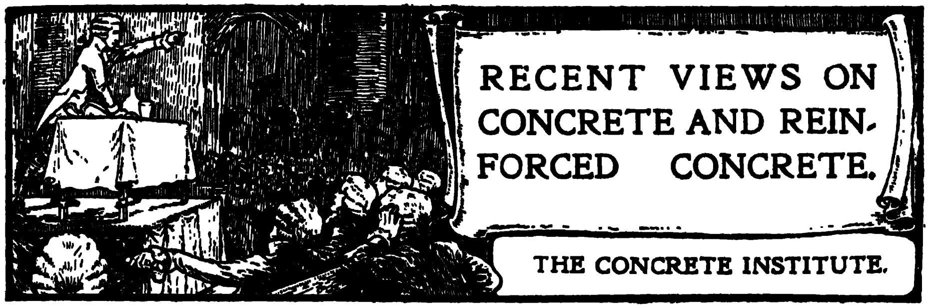
As the elevator is usually placed on the water front, and as its elevator boot tanks and receiving pits are necessarily some distance below grade, there is generally waterproofing to be taken into account. This is usually accomplished by means of the membrane system of waterproofing.

In regard to the balance of the construction, it is so nearly allied to other branches of reinforced concrete building that it is needless to go into further details.

In conclusion, it is fair to add that the modern elevator has been and will continue to be a great factor in the upbuilding of north-west and also western Canada, and, in conjunction with the railroads, the elevator has been responsible for the steady crop increase, until it is safe to predict that in the next half decade the wheat crop of Canada alone will exceed 500,000,000 bushels per annum.



TERMINAL ELEVATOR, FORT WILLIAM, ONTARIO, FOR THE GRAND TRUNK PACIFIC RAILWAY.



It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.
The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

CONCRETE IN ITS LEGAL ASPECT.

By W. VALENTINE BALL.

The following is an abstract of a Paper which was read at the Ordinary General Meeting of the Institute on January 9th, 1913.

PRELIMINARY.

In his opening remarks the author pointed out that there were certain difficulties in the presentation of this paper. There is no statute law which is specially applicable to the subject in hand, and of reported cases relating specially to concrete there are none. Nevertheless, there are certain aspects of the law relating to building and engineering contracts which may be of interest to members of the Institute. There are a few considerations which may properly be kept in view by the parties to a contract which involves the use of concrete or reinforced concrete.

In the course of the paper the term "employer" is to stand for the local authority, company, or person who requires the work to be carried out. The term "contractor" will signify the firm of contractors or builders employed directly by the employer, while the term "sub-contractor" will include any firm or company which is employed to carry out some portion of the work under a sub-contract.

GENERAL OBSERVATIONS ON THE EMPLOYMENT OF A SUB-CONTRACTOR.

In carrying out a large contract the employment of sub-contractors or specialists is very common; indeed, the employment of sub-contractors is almost inevitable when the work in hand is of any magnitude.

Generally speaking, where there is no stipulation against sub-contracting a contractor may employ sub-contractors. The rule is, however, subject to the qualification that it does not apply when the employer reasonably and naturally looks for the personal service and attention of the contractor. Thus, if the work in hand were of a highly special character, it would not be competent for the contractor who was skilled in that class of work to hand over its performance to some one else.

The following clause may be inserted if it is desired to ensure that the contractor shall carry out all the work himself :—

> "This contract is and shall be considered as a personal contract by the contractor himself, who shall personally, with the assistance of skilled foremen, agents, mechanics, and workmen, direct and execute the works."

The more approved practice, however, is to leave it to the engineer to say whether and how far sub-contractors may be employed. The following clause, which is to be found in the model conditions approved by the Institute of Electrical Engineers, may safely be used :—

> "The contractor shall not, without the consent in writing of the engineer, assign his contract, or any substantial part thereof, nor under-let the same, or any substantial

part thereof, nor make any sub-contract with any person or persons for the execution of any portion of the works, other than for raw materials, for minor details, or for any part of the whole of which the makers are named in the contract."

Another form of clause prevents the contractor from making a sub-contract with any workman or workmen for the execution of any portion of the work, except with the consent of the engineer. It also provides that if the contractor shall sub-let or let at task work any portion of the work he shall in such case forfeit to the employer the sum of £100 as liquidated damages.

WHO IS LIABLE TO PAY THE SUB-CONTRACTOR?

A most important question from the point of view of the sub-contractor is, Who is liable to pay him? He naturally wants to be sure that his labour will not be in vain. Generally speaking, the employer is not liable to a sub-contractor, unless an agreement between them can be proved. Such an agreement will not be implied from the mere acceptance of the sub-contractor's work. For instance, where an employer contracted with a builder to do certain work on his house, and a tradesman supplied goods to the builder for use on the house, it was held that the employer was not liable for their price (see the case of Brahmah *v.* Abingdon, cited in Paterson *v.* Gandasequi, 1812, 15 East. 62). The employer does, however, become liable if it can be shown that there is a contract between him and the sub-contractor.

An employer may also become liable to a sub-contractor by going surety for him. In that case, however, there must be something in writing, as a contract of guaranty cannot be sued on unless it is in writing. But there is a difference between a promise to pay the debt of another and a direct promise to be liable oneself in any event. In the latter case a written contract need not be proved. Thus, if the employer promises to pay the sub-contractor out of monies which he has to pay to the head contractor, this would be treated as a direct promise to pay (Dixon *v.* Hatfield, 1825, 2 Bing. 430).

There is another way in which the employer may become directly liable to a sub-contractor. It may be proved that the head contractor, in employing the sub-contractor, really acted as the agent for the employer. The *onus* of proving this will be on the sub-contractor (see Woodward *v.* Buchanan, 1870, L.R. 5 Q.B. 285).

The question, Who is the sub-contractor to look to for his remuneration? therefore turns upon the conditions of his employment.

The question of liability largely depends upon whether the contractor was constituted the agent of the employer to employ the sub-contractor or to purchase goods from him, and to establish privity of contract between the employer and such sub-contractor. Where the defendant (a building-owner) entered into a contract with a builder by which the latter agreed to build a house for him under the supervision of an architect, the contract provided that the provisional sums for goods to be ordered from special artists or tradesmen should, as the architect should certify, be payable by the builder or the building owner.

WHERE THE CONTRACTOR BECOMES INSOLVENT.

Trouble frequently arises in cases where, owing to the insolvency of the builder, the sub-contractor is compelled to look to the building-owner. He often makes such a claim without avail; but by means of a special clause this difficulty may be obviated.

HOW FAR THE CONTRACTOR IS LIABLE FOR THE DELAY OF THE SUB-CONTRACTOR.

If an employer reserves to himself the right of employing specialists to do any portion of the work on a large contract, he does not thereby give any implied undertaking to the head contractor that he will be responsible for any damage caused to the builder by any delay or default on the part of the specialists.

As a general rule, however, the sub-contract contains a clause to the effect that "the sub-contractor shall pay to the contractor a certain sum as liquidated damages, and not by way of penalty, per day for each day after the   day of   that the work shall not be finished or complete, and it shall be lawful for the said contractor to retain the said sums out of any money payable to the sub-contractor."

LIABILITY OF THE SUB-CONTRACTOR FOR DELAY.

The liability of a sub-contractor for delay in completing the work he has undertaken to carry out depends on the terms of his contract with the head contractor. If

he does not know that the head contractor has undertaken to do the work within a specified time he will not be liable for the damages claimed and recovered by the employer for delay; but it is otherwise if it is shown that he knew what would be the consequences of delay. To quote the case of The Hydraulic Engineering Co. *v.* McHaffie, 1878, 4 Q.B.D. 670, the plaintiff company contracted with an employer to make a pile-driving machine. The defendant was employed to make a part of the machine and to deliver the same by the end of August, when, as he knew, the plaintiff company had to make delivery to the employer. The defendant was a month late in making delivery of his part, with the result that the employer refused to accept the whole machine. As it was of peculiar construction no market could be found for it, and it was therefore sold as old iron. It was held that the plaintiffs were entitled to recover the profits which they would have made on the sale to the employer and the expenditure thrown away on the other parts of the machine. From this it may be inferred that any sub-contractor for the execution of a portion of a contract for large works may find himself cast in very considerable damages if he is guilty of delay.

USE OF MATERIAL ON THE SITE.

It may well be that in some cases the builder or other person who has to provide concrete will find a large bed of gravel or other useful material on the site. How far can he use it in the fulfilment of his contract?

An obligation upon a contractor to clear away old materials does not necessarily vest those materials in him. Again, where a contractor is bound by his contract to excavate, the materials excavated do not necessarily vest in him. On the contrary, if a contractor make use of materials supplied to him the employer may set off their price against the amount due under the contract. For instance, in one case the plaintiff contracted to do certain work for the defendant and to find the materials. The defendant supplied part of the materials which the plaintiff made use of in the work. It was held that the defendant was entitled to deduct the value of the materials supplied by him from the contract price (Newton *v.* Forster, 1844, 12 M. and W. 772).

The importance to the employer of some clause dealing with old materials lies in the fact that if nothing is said about them the contractor may remove them. Having removed them he may sell them. In that case, if he were to become bankrupt, the employer could not get the goods back, but would be relegated to his right of proving for their value in the contractor's bankruptcy.

Where the contract for erecting a building or executing other works makes no reference to old materials, it seems that the contractor will be under an implied obligation to clear them away. There is no English case directly in point, but the principle has been laid down in several American cases.

IMPORTANCE OF PROVIDING FOR THE REMOVAL OF OLD MATERIALS.

It is well for every contractor who has undertaken works which involve the clearance of a site to take care that he is adequately protected. The removal of a large mass of concrete would be a long and costly operation, while to remove reinforced concrete, knit together with ribs of steel, is the labour of Titans. When the time arrives for the removal of modern buildings it is clear that the contractor must needs regard clearances as a very important item when considering the amount of his tender.

EXPRESS PROVISION FOR MATERIALS ON SITE.

In drawing his specification the architect often inserts a clause to the following effect, "Materials on the site to be used as far as possible." If a tender is made by a contractor on the basis of such a specification the architect should take care to ascertain whether the contractor has made any deduction in respect of old materials. If the contractor, having made no deduction, uses any of the materials the architect may set their value off against the contract price; and even if the contractor has made a deduction, but has not informed the architect of the fact, there may still be a set-off.

CLAUSE TO PROVIDE FOR THE USE OF OLD MATERIALS.

The following is a convenient form of clause:—

"All materials upon the site or upon the space to be covered by the buildings [or contract works] at the date of the contract, and all materials and things excavated by the

contractor from the works, shall remain the property of the employer until paid for by the contractor. Such of them as shall be approved by the architect for the purpose of the works shall be paid for by the contractor at a price to be named in his tender or, if not named, to be ascertained by the architect, and all other materials shall be removed by the contractor from or deposited, stacked, or spread on the site as, where and when directed by the architect."

This clause may properly be inserted in a contract which involves the making of concrete, because it is necessary that gravel, etc., to be used should be approved by the architect.

PROVISION FOR WATER.

Another question of importance is the provision of an adequate supply of water. Where there is a good supply at hand in the mains no difficulty need arise. The question will simply be, Is the employer or the contractor to pay the water rate during the work of construction? But if there is no municipal or other supply the difficulty may have to be met by sinking a well or pumping from a lake or river. Suitable clauses must be inserted in the contract to place the burden of pumping or well-sinking on the right shoulders.

RIGHT TO REJECT MATERIALS.

It is important to consider the question whether the architect has the right to reject improper materials when brought on to the works. In this regard the provisions of the R.I.B.A. form appear to be fairly satisfactory.

SUPERVISION WHEN CONCRETE BEING LAID.

Concrete is a matter which may require some supervision on the part of the architect. To cover up wet concrete may involve serious disaster, and it seems that, in the conduct of ordinary building operations, it is the duty of the architect to attend to this matter; although in some respects he is an arbitrator, he is also a servant to the building-owner or employer.

"There may, of course, be many things which the architect cannot be expected to observe whilst they are being done—minute matters that nothing but daily or even hourly watching could keep a check upon. . . . . But he, or someone representing him, should undoubtedly see to the principal parts of the work before they are hid from view, and if need be he should require a contractor to give notice before an operation is to be done which will prevent his so inspecting an important part of the work as to be able to give his certificate upon knowledge, and not on assumption, as to how work hidden from view has been done."

So much for the liability of the architect. In a case where there is no architect employed the problem assumes a somewhat simpler aspect. The builder then acts as skilled adviser, as designer, and as superintendent of the building.

DEFECTS AFTER COMPLETION.

The author stated he had not sufficient technical knowledge to know whether concrete or reinforced concrete is liable through the mere lapse of time to deteriorate. Take, for instance, the case of a concrete archway. Suppose that it develops a crack within six months of the date of completion, and the contract is silent on the question of liability—what is the legal position? The mere fact that the employer has accepted the bridge and paid for it would not amount to a waiver of his right to damages if the bridge failed through some fault for which the contractor was responsible.

For instance, in one case the plaintiff, a shipowner, bought copper sheathing of the defendant, a copper manufacturer, and the copper was put on the ship, which sailed; but the copper, instead of lasting four or five years, as usual, corroded in four or five months and became unfit. It was held that the plaintiff could recover damages, notwithstanding the acceptance (Jones *v.* Bright, 1829, 5 Bing. 533).

Further, payment of, or judgment for, the contract price is no bar to claim by the employer for defective work, nor for damages arising out of the breach (Davis *v.* Hedges, 1871, L.R. 6 Q.B. 687).

ADVANTAGE OF HAVING A TIME LIMIT TO LIABILITY FOR DEFECTS.

From the point of view of the contractor who has to put in concrete, it is best to put a definite period to his liability by an express clause in the contract, because where work is agreed to be done to the approval of the employer or his architect, the expres-

sion of that approval will prevent any recovery by him for *patent* defects subsequently discovered.

Where the contract is silent in the matter, the measure of damages for incomplete or defective performance is what it would cost to rectify the defects or omissions at the date when they might have been discovered, or when the particular part of the work was completed.

Apart from the terms of the contract, it is manifest that the contractor could not by any possibility be held responsible for defects arising in the course of time from wear and tear. But if there is a structural defect which ought to have been detected and put right when the works were in hand, it is conceived that the contractor remains liable for that.

UNFORESEEN DIFFICULTIES IN CARRYING OUT THE WORK.

There is one matter to which the contractor who has made himself responsible for the laying of a large bed of concrete must pay particular attention. The employer will endeavour to put upon the contractor the entire responsibility for the site—the nature of the strata to be met with when making excavations and their capacity to support the intended structure; and he will also seek to put upon the contractor the responsibility of estimating how much material will be necessary to complete the work.

It is a well-established principle of law that in the performance of an ordinary building agreement or other contract for works, the risk of possibility of performance is on the contractor. (Thorn *v.* Mayor of London, 1876, L.R. 1 A.C. 120.)

The principle of Thorn *v.* Mayor of London was long applied to excuse employers in cases of a similar kind; but a more recent case has shown that the disclaiming clause will not necessarily relieve the employer. If he puts forward plans, etc., as showing the nature and extent of the work, he may be held liable if those plans were false to his knowledge or were put forward recklessly without proper inquiry as to whether they were true or false.

CLAUSES DEALING WITH CEMENT.

Certain points seem to require attention in contracts relating to the supply of cement. Thus, provision must be made for testing by a person responsible to the employer, and for suitable accommodation in a dry place. In the case of a very large contract it may be necessary to erect a special building for the storage of cement until it is required for use. In that case it will be necessary to specify who is to erect the building.

CONCLUSION.

In concluding, the author remarked that after his paper had appeared in print, he had received a copy of Messrs. Scott-Fraser's specification of reinforced concrete which was published in 1911, and contained some general and preliminary clauses. This specification, the author remarked, appeared to be drawn in a form which might be usefully adopted by those who have to carry out this kind of work.

Before opening the discussion the President read a letter from Mr. Percy Waldram, F.S.I., M.C.I.

Extract from Mr. Waldram's Letter.

"Mr. Ball's interesting and valuable paper would appear to have omitted one point, which might possibly be of the greatest possible importance, viz:

"Who is responsible in the event of failures due to over-daring design?

"In many cases where reinforced concrete is used the engineer or architect is not in a position to check the calculations. He employs a specialist firm to design and calculate the work, receives from them a price, and instructs the general contractor to give them the order. The latter merely carries out that instruction. In due course the specialist firm send on to the work, not their own workmen, but the workmen of a second sub-contractor employed by them. In the case of a public contract not long ago, the Local Government Board Inspector asked who would be responsible for the accuracy of the calculations. The prospective contractor was in this case a licensee of the specialists' system. He promptly disclaimed responsibility for calculations which he had never seen, and could not follow if he had. The local engineer said the same, whilst the specialists replied that they were employed to design only, and that if they designed in accordance with ordinary practice their responsibility was at an end; they were not parties to the contract, and had no more responsibility than the local engineer.

"Probably all three were perfectly correct, but the members of the local Council were not impressed.

"It is not always easy to get proper calculations.

"Still more difficult would be the case where a failure occurred with regard to some of the matters upon which we are still somewhat hazy. Even the R.I.B.A. Reports and the proposed L.C.C. Regulations are almost entirely silent with regard to double reinforced beams.

"Possibly Mr. Ball could suggest some form of undertaking which would fix the responsibility for reinforced concrete work upon the shoulders of the specialist firms who design it, and upon their sub-contractors who carry it out, and also state whether that undertaking could be a joint and several one, and for how long it would operate in the event of no time limit being stated."

DISCUSSION.

Mr. A. Alban H. Scott, M.S.A. (Member of Council C.I.), said Mr. Waldram's letter raised some of the most important points that can be raised with regard to reinforced concrete work. The usual custom in building contracts has been, and is being, unfortunately entirely departed from in reinforced concrete work.

He said there were five methods specially in vogue at the present time where the reinforced concrete specialist came in, and, after dealing with them in detail, said that with the various cases quoted as to sub-contractors it is placing both the architect, and eventually the building owner, from a financial point of view, in a most extraordinary position, because he at least, as a layman, has no idea where he stands at all.

The only thing that would appear to cover him is the usual clause in the R.I.B.A. form with regard to sub-letting, which is a very short and concise clause. It simply says that the contractor shall not sub-let without the architect's written sanction.

So far as the builder and the sub-contractor are concerned with regard to penalties, the Master Builders' Association have a sub-contractors' form which is based on the R.I.B.A. form, and it there gives in the form of a schedule the whole of the main contract so far as it applies to the sub-contractor, and the sub-contractor has a right to inspect the main contract. It is a very good contract.

In the course of the paper it is stated that the architect should require a contractor to give notice before an operation is to be done; it will prevent his inspecting the important part of the work, in giving a certificate on knowledge and not upon estimation. In reinforced concrete work, unfortunately, every part of the work is hidden which is of importance, and even if an architect spent the whole of his time on the job he would have to have a dozen pair of eyes and a dozen personalities on a fair-sized job.

Mr. W. G. Perkins (District Surveyor for Holborn; Member of Council C.I.): In the early part of the paper it is stated there is no statute law which is specially applicable to the subject in hand. There are the London Building Acts proposed regulations which would govern reinforced concrete, and the bye-laws governing concrete in foundations in London, in foundations outside of London, and the construction of walls in London.

Looking at the paper from the official point of view, it would be very interesting if the author would express his views as to the contractor's position with regard to this Building Act and the bye-laws just mentioned. Many instances similar to the following one have come to his notice. The specification furnished by the architect described certain concrete for a wall to be composed of one part of cement to six parts of aggregate. The bye-law requires concrete for the work in question to be one part of cement, two parts of sand and three parts of aggregate, and the local authority (the speaker in this case) insisted upon the work being done accordingly. One of the conditions of the contract stated that the whole of the work was to be in accordance with the bye-laws, and to the satisfaction of the local authority. In such a case, can the builder, having regard to this clause, claim an extra payment for the additional amount of cement used, for the sand, and for the extra labour in mixing the concrete when composed in accordance with the bye-law?—that is to say, he has to handle three materials instead of two.

Mr. Flander Etchells quoted a number of Building Acts and Bye-laws where concrete or reinforced concrete are mentioned in an ambiguous way.

Mr. Osborne C. Hills, F.R.I.B.A., Member of Council C.I. (District Surveyor for the Strand) asked the Lecturer what he thought was the position to-day of the architect who specifies reinforced concrete floors he cannot supervise. There was the case of a floor not a mile away from the meeting place with a certain amount of steel work. The proper amount of steel work was provided for. At the end of the job a certain amount of steel was carted away, and it was not known how the surplus was come by. After some searching it was discovered at last that there is a whole bay of concrete, a 17-ft. span, and not one iota of the steel rests there. Is the architect responsible for that? Now it has been discovered, it is

going to be put right; but, had it not been discovered and an accident had happened, surely the architect would not be responsible for it?

Mr. Herbert Shepherd, A.R.I.B.A., M.C.I., said he did not agree with Mr. Etchells or Mr. Hills. If they looked back to the 'fifties they will see that at that time concrete was being advertised and was being dealt with then in a very large way all over the country as the "new material." They were actually building concrete houses in the North of England at that time. The 1855 Act originated out of a request to the Government of the day by the Royal Institute of British Architects to assist them in reforming what was then called "The Metropolitan Building Act," and it was with their assistance principally, and with the aid of the Royal Institute, that those draft regulations were first brought into being. And the interesting part is this, that the very first lecture that was ever given, and the very first prize that was ever given by the Royal Institute of British Architects, was in 1834, for a paper on concrete.

It seemed an anomaly to him that even at the present day, in spite of the revisions which the Building Acts have received from the progress of construction, he believed it is still possible that one can legally put 9 inches of concrete under a wall 80 ft. high.

MR. VALENTINE BALL'S REPLY.

Mr. Valentine Ball, replying to the points raised by Mr. Scott, said, in the case of the specialist employed by the architect, he thought with regard to the liability of the contractor for the specialist, that had been to some extent foreseen in the R.I.B.A. Form, Clause 20, where it will be found that the contractor is entitled to object to the employment of any specialist who will not enter into a contract with him indemnifying him from the consequences of the specialist's fault and delay; and that, he supposed, in some measure afforded protection to the contractor.

But as to the general question, who is liable for a fault in design, the decisions on the point appear to show that if the employer engages a contractor to use a particular kind of patent roofing, and stipulated no other should be used, and the patent roofing turned out to be wholly incapable of keeping out the wet, then the responsibility is not upon the contractor. He simply did what he was told; but as to the exact position where the designs of the engineer, as worked out by the specialist, are faulty, then again, he supposed, the liability would be on the engineer or the architect.

With regard to the question of the inspection of reinforced concrete by the architect when it is in the lay, it appeared to him that the modern class of building contract does not provide exactly what the duties of the architect shall be, and it seemed utterly unreasonable to suppose that the architect must be there when every piece of steel is being put into place, or that any Court of Justice would hold that that was the duty of the architect. He could perhaps protect himself by insisting that more than one clerk of the works shall be employed, and that the clerk of the works shall be careful to exercise due diligence in supervising the contractor.

Answering the interesting question raised by Mr. Perkins with regard to the observance of by-laws by the builder, the R.I.B.A. Form expressly provides for that by Clause 5, where the duty of complying with by-laws past, present and future is thrown upon the builder. If he finds, in carrying out the work, that he cannot comply with the by-law by complying with the specifications, he was entitled to give notice to the architect and say he must comply with the by-law, and if he complied with the by-law, he would be entitled to treat everything—all the expenses which he so incurred—as an extra under the contract, in accordance with Clause 13 of the Form, just as other extras are dealt with. In the very recent case of John Barker and Co. against the Hurlingham Club, where the whole question of extras was gone into, and, notwithstanding the opinion of the architect, the builder was entitled to treat compliance with by-laws as an extra, an omission.

In conclusion, the lecturer promised to give written replies to several other questions which might be raised.

THE INSTITUTION OF CIVIL ENGINEERS.

THE CANTON-KOWLOON RAILWAY: CHINESE SECTION.

By FRANK GROVE, M.Inst.C.E., and
BASIL TANFIELD BERIDGE BOOTHBY, Assoc.M.Inst.C.E.

The following is a short abstract of a Paper read at the Ordinary Meeting of the Institution on January 28th, 1913.

THIS Paper is in two parts, the first, by Mr. Grove, dealing with the general construc-

tion and equipment, while the second, by Mr. Boothby, is an account of the largest two bridges of the East River Delta.

The Canton-Kowloon Railway has been constructed in two sections: one, eighty-nine miles in length, in Chinese territory, from Canton to the Shum-chun River, the northern limit of the British leased territory in the Kowloon peninsula; the other, twenty-two miles long, through the latter territory to Kowloon. The former section has been built by the British and Chinese Corporation; the latter by the Colonial Government.

The Chinese section of the line crosses the East River at Sheklung. The first thirty miles from Canton is alluvial plain not subject to heavy floods; the next twenty-six miles crosses the East River and its tributaries and is subject to heavy floods; while the last thirty-three miles is for the most part hilly country with intervening plains.

The East River valley, which is about forty miles in width, is deltaic, and in the ten miles between mile 31 and mile 41 there are seven bridges, aggregating thirty-one spans, with a total length of 3,248 ft.

The cultivated ground throughout the East River valley length is 7 ft. to 11 ft. 6 in. below the highest known flood. For purposes of cultivation the whole area is protected by high bunds or banks. Formation was carried 2 ft. 6 in. above the highest flood record for thirty years, which gave a bank averaging for many miles 14 ft. high, and at approaches 24 ft. or more. These banks have been protected against wave- and flood-erosion by stone pitching. In times of excessive flood many miles of this portion of the line will be a causeway through open water 8 or 10 ft. deep. Its security will be aided materially by proper maintenance of the pitching; while the fact that floods rise slowly and backing up takes place evenly on both sides of the bank gives additional security.

Earthwork and all other works were carried out by petty contract. About 350 contracts were entered into with Chinese contractors. Day-labour gangs were mostly confined to special bridgework, such as caisson-sinking, pumping, etc.

The minor bridges and culverts and all the large bridges but three were built in cement concrete. Good cheap cement and good sand were procurable locally; but the objection of the Chinese to quarrying their native hills gave rise to considerable difficulty in obtaining stone, and granite for the larger bridges had to be brought from Hong-Kong, although good local stone was plentiful.

The steelwork for the bridges was designed by the consulting engineers to the British and Chinese Corporation (Sir John Wolfe Barry and Mr. A. J. Barry), and was built in England under their inspection. It was designed generally in accordance with the standard Indian practice, but for a standard loading 10 per cent. above the Indian standard loading of 1903, having regard to the probable requirements of the future.

There are fourteen stations and thirteen halts. With the exception of the Canton terminus, all the stations are of the simplest character possible having regard to existing requirements. The platforms, except at Canton, are 6 in. above rail-level.

The two bridges described in the second part of the paper are those over the East River and the Tung Kun River. Each has two shore spans of 60 ft., consisting of plate girders, while the waterway is bridged in the former with three and in the latter with four 224-ft. spans of Warren girders. The East River at Sheklung has a maximum tide of 3 ft., and its low winter level is 7 ft. above Admiralty datum at Hong-Kong.

Borings showed red marl at 30 to 65 ft. below low water; the overlying material varied between sand and mud, coarse sand predominating. It was proposed to sink caissons 2 or 3 ft. into the marl, but it proved to be practically rock, and the depth proposed could not be reached.

A contract for the concrete and masonry was let to Mr. Y. T. Chao, a Chinese contractor, and was successfully carried out by him, notwithstanding delays and obstruction and serious commotion among the populace caused by the importation of northern coolies. Well-sinking and girder-erection was carried out departmentally, with petty contracts for riveting and other work where possible.

Double octagonal caissons and curbs 38 ft. by 21 ft. 9 in. were adopted for the piers of the main spans, the steelwork being built at Hong-Kong and sent up to Sheklung in sections. The bottom ring of each caisson was built on a cradle on launching-ways, and, when riveted and caulked, was launched. The second and third

rings, making a total height of 23 ft. (East River caissons) were then added, and when concreted to a draught of 16 ft. the caisson was towed to the site, its position being adjusted by anchors. The caissons for the Tung Kun bridge were 14 ft. deep, and of two rings only. They were built at the East River launching-ways and had to be towed and warped three miles to the Tung Kun bridge, which, owing to the resistance offered by each double octagonal caisson in even a moderate current, proved to be a very troublesome task. One caisson broke loose and fouled the caisson for No. 3 pier of the East River bridge, which was in position ready for pitching and already concreted to a draught of 16 ft.; two days later both caissons were carried down-stream together, but were stopped by the deeper grounding on a sandbank about a quarter of a mile below the bridge, whence both were recovered.

Concrete was used for steining the walls, and was brought up in lifts of 4 to 7 ft., the same shutters being used over and over again. On the whole the use of concrete proved very satisfactory, especially in giving weight for sinking, which, in the author's opinion, is of the utmost importance. The double octagonal caisson-walls were 5 ft. 6 in. apart, and this thickness was carried up in the well-walls until the pier-footings were reached, providing a sinking force of 5 cwt. to 8 cwt. per sq. ft. of underground surface when the well was nearing foundation-level.

In the foundations of two of the Tung Kun piers steeply sloping sandstone rock was encountered, and the caisson of one pier tilted 1 ft. 9 in., divers finding that while the west side was in the rock the east side was still in sand. The east well was then filled with sand, and by blasting around the cutting edge in the west well the pier was sunk another 1½ ft. As it was found that the east well was then on rock all round, the pier was founded thus, the masonry having to be partly dismantled and rebuilt owing to the tilt of the pier.

The 224-ft. Warren girders have eleven bays, which are 21 ft. between the centres of triangulation both vertically and horizontally. They are for a single line, and are decked with ⅜-in. steel plate, the rails being carried on longitudinal hardwood sleepers. The complete weight of each 224-ft. span is about 350 tons.

After being erected one behind the other on shore, the spans were pushed forward, by means of hydraulic jacks, on to the ends of launching-jetties, and there lifted on a crib of sleepers by 100-ton ship jacks. Docks had been prepared inside the launching-jetties and when a span had been raised to the proper height on the jetties pontoons were brought under in a flooded condition. On these pontoons, when pumped out, the spans were floated into position. Each launch took one and a quarter to three hours.

Mr. Grove was the Engineer-in-Chief, Mr. Boothby being the District Engineer of the Second Section.

NEW WORKS IN CONCRETE

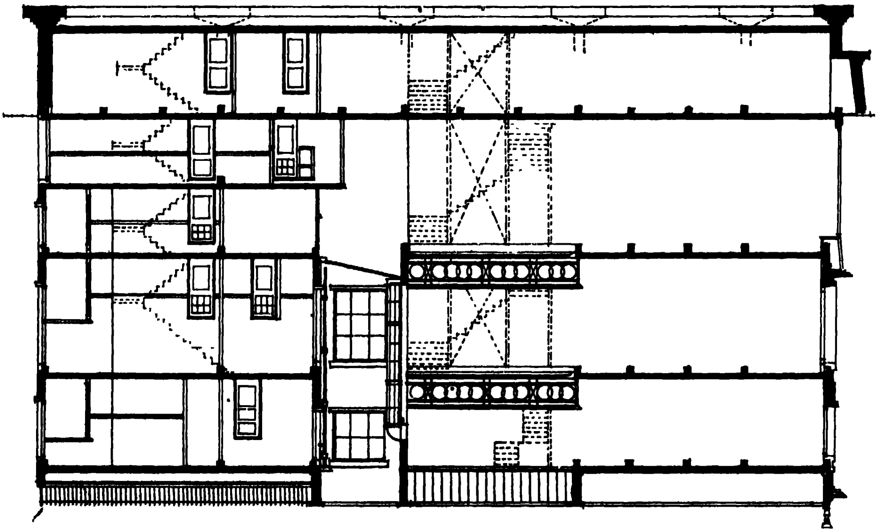
AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

NEW BUSINESS PREMISES IN REINFORCED CONCRETE AT MIDDLESBROUGH.

The following are some particulars of the new premises recently opened for Messrs. Newhouse, Ltd., in Middlesbrough. The premises comprise large drapery stores, and reinforced concrete formed the chief constructional material, it being used for the entire internal construction. There are some unusual features in this particular building to which we would draw attention.

Owing to the impossibility of obtaining sufficient depth for some of the main beams carrying exceptionally heavy loads, spiral armouring was introduced into the



Section.

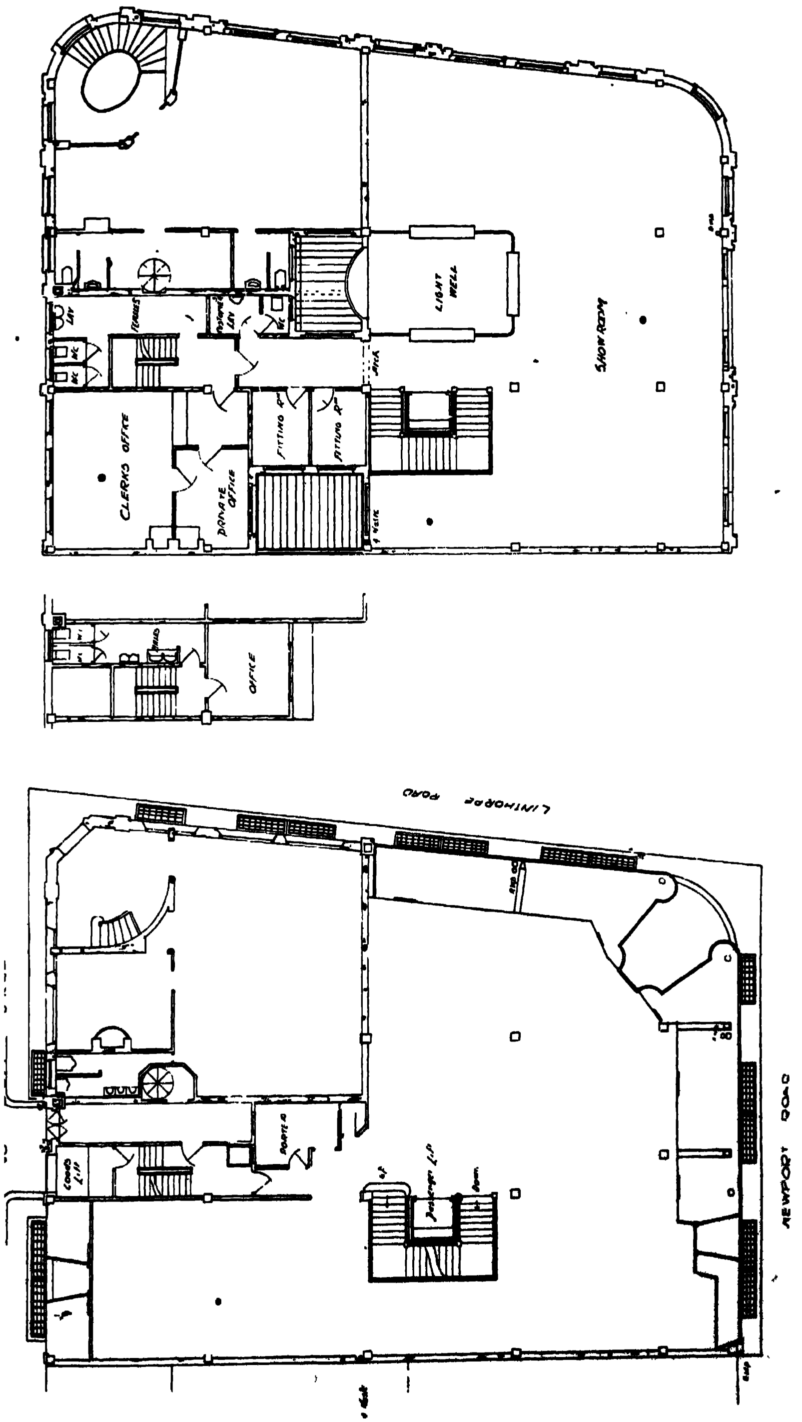
New Premises for Messrs. Newhouse, Ltd., Middlesbrough.

top part of the beams at the centre of the span so as to increase the resistance of the plain concrete and thus enable the designers to exceed the usual limit of stress in concrete of 600 lb. per sq. in.

Our illustration on page 206 shows the reinforcement of a beam of this type in position. It will be noted that the stirrups are hooked into the concrete at their upper extremities.

The irregular shape of the site also made the question of designing the beams particularly difficult, as the bending moments had to be calculated for points and distributed loads of varying amounts on beams continuous over spans of different lengths.

To give some idea of the size of the premises, we would mention that the total area of the ground floor, exclusive of window space, is 28,459 sq. ft., the showrooms and fitting-rooms have an area of 2,513 sq. ft., whilst the workrooms occupy 3,863 ft.



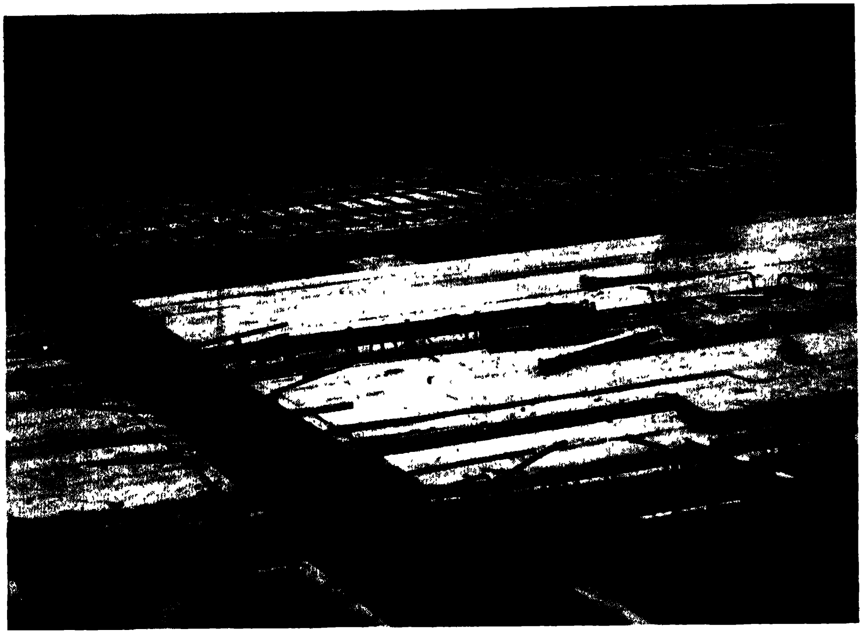
FIRST FLOOR PLAN

GROUND FLOOR PLAN

NEW PREMISES FOR MESSRS. NEWHOUSE, LTD., MIDDLESBROUGH.

The use of reinforced concrete in buildings of this kind is of the greatest advantage and importance on account of its fire-resistance.

The designs of the reinforced concrete system here adopted were those of the Considère Construction Co., Ltd., of Westminster, S.W., and the work was carried out by their licensee contractor, Mr. E. Newhouse, of Middlesbrough.



Reinforcement of Beam.

NEW PREMISES FOR MESSRS. NEWHOUSE, LTD., MIDDLESBROUGH.

CONCRETE BLOCK COVE TO SHAND WALL.

THE wall illustrated on page 207 is made of "Winget" blocks, and is 388 ft. long and 19 ft. 6 in. high, 3,713 blocks being used in its construction. The blocks were built on the batter and kept slightly in advance of the depth of shuttering at the back when concrete *in situ* was filled in. The work was carried out by the Ilfracombe Urban District Council under the direction of Mr. Oswald M. Prouse, A.M.Inst.C.E., Surveyor and Harbour Engineer to the Council.

Similar blocks were used by the Council on other works carried out by them, including Forty-steps Wall, the Manor Stables, the Stone Depôt, etc.

SOME AMERICAN EXAMPLES.

CONCRETE MARKET HOUSE, FORT WAYNE, INDIANA.

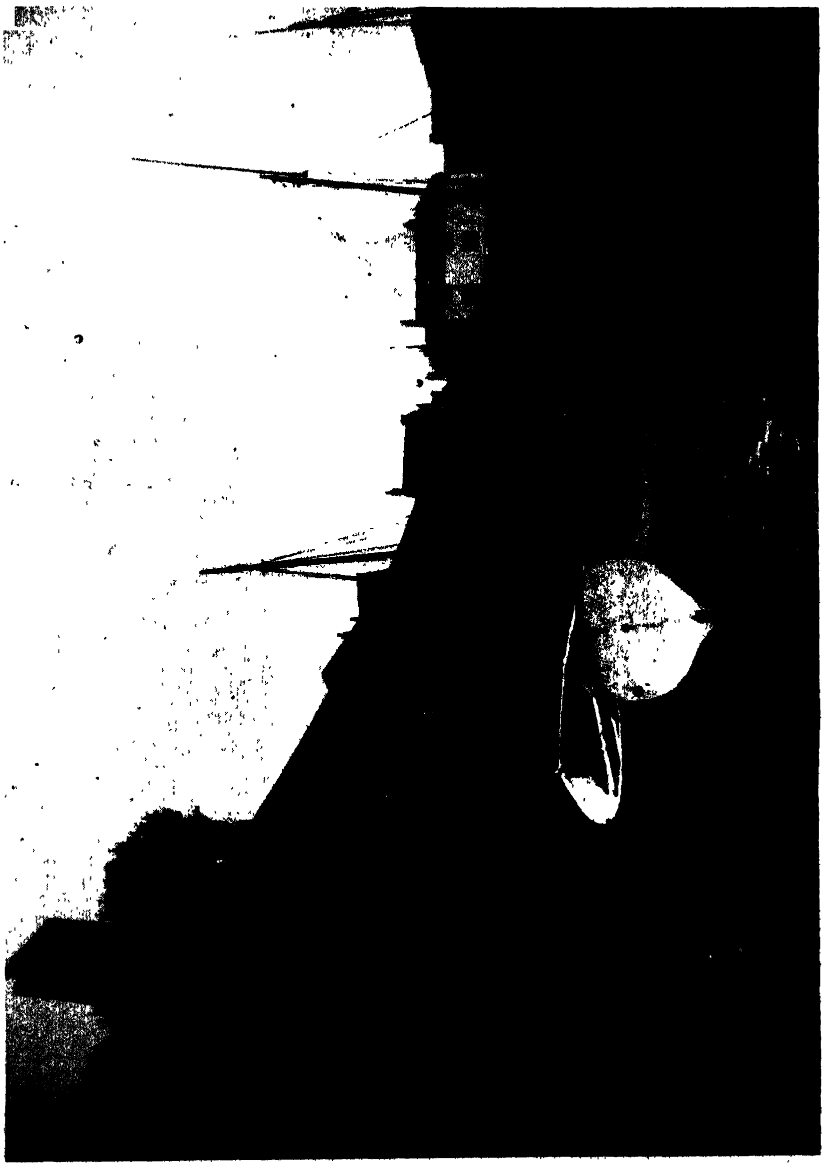
CONCRETE will enter most effectively into constructions of all kinds when its real value is understood, from the point of ornamentation as well as durability.

The Market House, here described, is just south of the city hall. Its two pavilions are the chief decorative features of the structure, being connected by steel arches profusely strung with electric lights. There is a similar pavilion, no less ornate, at the further end of the structure.

The entire length is 450 ft., and the width of the structure from curb to curb is 26 ft. 5 in. The general scheme of architecture is classical, the pavilions being of the Ionic order. These pavilions, although built upon a core of brickwork, present an unbroken surface of concrete to the observer. It is concrete of a peculiarly pleasing

surface, being made of white sand and Medusa white cement, with an aggregate of bird's eye or roofing gravel.

When the forms were removed the surface was scrubbed with wire brushes, exposing the aggregate. The capitals of the columns were cast in glue moulds, and other ornamental features, such as rosettes, keystones, etc., were cast in plaster moulds



and set in place as the structure went up. The columns were cast in place in the same manner as the columns for the main part of the structure, hereafter described. The drinking fountains were cast in place, complete with pipes, etc. These pavilions contain the market master's office, as well as public toilet rooms, etc. In the main part of the structure there are fifty-four round columns, together with two square

columns at the end which backs up to the valley near the city hall. These round columns have a shaft of 8 ft. 9 in., resting on an octagonal base varying in height with the slope of the ground. The shaft of each column is 24 in. in diameter at the base, and 21 in. at the top, and each is surmounted with plain moulded capital and square cap.

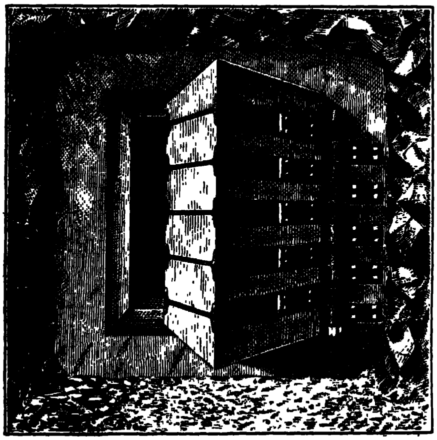
CONCRETE MARKET HOUSE, FORT WAYNE, INDIANA, U.S.A.

The method of construction of these columns is as follows: A rough core was first cast of a mixture of one to five. This core was made 6 in. less in diameter than the finished columns, allowing the finished cast to be 3 in. in thickness all round. When the core had hardened, the forms were removed and the mould was put in place around

this for the complete column. This mould was built of wood, in four sections, with very carefully finished surfaces, and into this was poured the finish concrete, of the same mixture as described for the surface of the pavilions. The proportions of this concrete were one of white cement, two of white sand and three of the roofing gravel. Medusa waterproofing compound was also used in all of the concrete to the extent of about 1½ or 2 per cent. of the amount of cement. The forms were removed and the surface brushed after twenty-four hours. Long bolts were imbedded in the tops of the columns, extending upward for the purpose of anchoring the roof. For the purpose of accommodating these, a circular opening was cast in the caps of the columns, and this opening, after the caps were in place, was filled with concrete, thus serving the double purpose of holding the caps in place and also giving an additional anchorage to the bolts.

The roof has a framework of wood, covered with red roofing tile. A concrete floor is laid over the entire structure. The tables are also of concrete, and are 112 in number, two tables being placed in each opening between columns. These tables are 5 ft. long, 2½ ft. wide, and will stand 2 ft. 10 in. above the floor. The legs are cast solid, but of slightly ornamental design. They are 4 in. thick, reinforced with a sheet of expanded metal, and were cast in a plaster mould, made in four parts on a wood frame. This mould simply consisted of the four sides clamped together and laid on concrete floor which was covered with oil paper. The concrete was then poured in, and the top trowelled off smooth. These legs and the tables themselves were made of a one to two mixture of ordinary grey cement and washed sand. The tables are 1¾ in. thick, reinforced with a sheet of Page woven wire, and have a flange of about 3 in. extending around three sides, and they are also cast on a concrete floor in steel mould especially made for the purpose. The tables are bolted to the legs with four bolts, two being imbedded in each leg, and holes being provided for by the form for the tables themselves. These bolt holes are countersunk with a small trowel.

The architects for this building were Messrs. Mahurin and Mahurin, and the contractors Messrs. Borkhenstein and Son, all of Fort Wayne, Indiana.



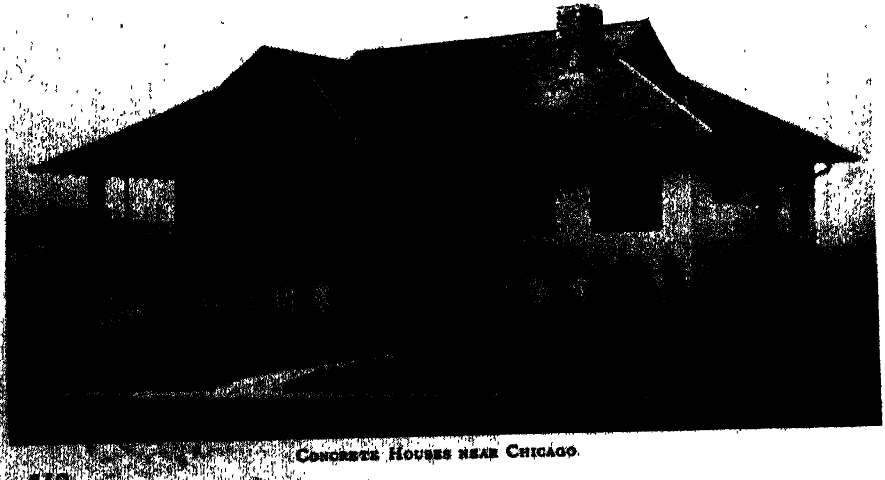
A 2-Ton Reinforced Concrete Door for Tunnel Work.

SOME CONCRETE HOUSES IN A CHICAGO SUBURB.

Our illustrations show some concrete bungalows recently erected at High Lake, one of Chicago's suburbs. It is reported that some forty houses in reinforced concrete are also now nearing completion at Nanticoke, Pa., U.S.A., where the walls are entirely of cinder concrete built by the use of steel forms, as was the case with the houses illustrated on page 210.

SAFETY DEVICE FOR TUNNEL WORK.

A Reinforced Concrete Door.—In connection with the new pressure tunnels now being driven beneath New York City for the Catskill water supply an interesting device is to be noted for storing the dynamite used for blasting in the tunnel. A dynamite room has been hollowed out of the solid rock 250 ft. underground and connected to the tunnel by a narrow passage about 20 ft. long. At the end of this passage nearest the storeroom a massive concrete frame has been keyed into the rock walls, bevelled at an angle of 20°. This frame has been fitted with a reinforced concrete door similarly bevelled, as will be seen from the illustration. This door is built up around five 15-in. I-beams with reinforcing rods passing through and between them, and it swings on a 3-in. steel pin. The weight of the door is 2 tons. The door is arranged to only open two-thirds the full way, and its objects are to reduce the force of the shock in the tunnel in the event of an explosion of stored dynamite and to protect the



CONCRETE HOUSES NEAR CHICAGO.

dynamite from excessive shocks from blasts in the tunnel, as in either case the door would be closed by the difference between the air pressures on the two sides.

We are indebted to the *Engineering News*, U.S.A., for our illustration and particulars.

A REINFORCED CONCRETE HOTEL IN THE PHILIPPINES.

The new Manila Hotel recently completed is reported as being not only the largest but also the costliest structure in the Far East, and it is undoubtedly the largest in the Philippines.

The building is constructed in concrete and steel throughout, with the exception of some of the floors and ceilings in the larger rooms, where highly polished Philippine hardwoods were employed. There are seven stories from basement-level.

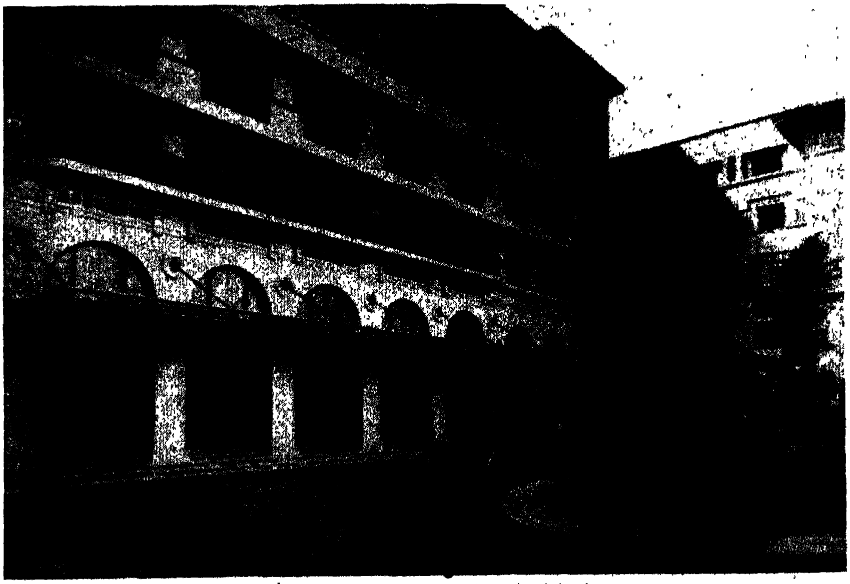
The hotel is well equipped; all the most modern steam and electric cooking apparatus being installed. There are steaming and refrigerating equipments on the roof garden floors and in the reception halls for heating and cooling food.

Every convenience is to be found in the hotel in the way of large reception-rooms, billiard-rooms, etc. There are several roof gardens, verandahs, and balconies.

The building rests on a solid foundation of hardwood piling driven to a depth of 52 ft. 6 in., and, with the grounds belonging to it, covers a very extensive area. The grounds are laid out tastefully and attractively with lawns, shelled drives, sunken gardens, and fountains.

The building was erected at a cost of nearly $50,000, and native labour was used to a great extent under the direction of American superintendence.

We are indebted to *Concrete-Cement Age* for the illustration and particulars of this building, as also of the houses illustrated on page 210.



THE NEW MANILA HOTEL, PHILIPPINE ISLANDS.

NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

"Estimating for Reinforced Concrete Work." By T. E. Coleman.

London B T Batsford, 94 High Holborn 143 pp +x, price 4/- net

Contents.—Introduction—General Principles of Construction—Measurement of Reinforced Concrete Work—Materials for Concrete—Surface Finishing for Concrete—Prices for Concrete Work—Prime Cost of Materials for Concrete—Analysis of Prices for Concrete—Carpenters' Work—Materials for Centering—Prices for Centering, Sheeting, etc.—Analysis of Prices—Materials for Metal Reinforcement — Reinforcement Systems for Concrete—Prices for Smiths' Work—Analysis of Prices for Steel Reinforcement—Materials for Reinforced Concrete Piles—Systems of Reinforcement for Concrete Piles—Prices for Reinforced Concrete Piles—Prices for Piles Complete—Ordinary Steel and Concrete Construction — Reinforced Concrete for Special Purposes.

This is a very useful little book dealing with the measurement and pricing of reinforced concrete work. A portion of the matter recently appeared in a series of articles in the *Building News*, and additional notes and prices have been added and the whole carefully revised to date. The items and prices are based on the average cost of materials and labour in the London district, and consequently adjustments must be made, if necessary, to suit varying local conditions.

The materials for concrete, and also surface finishings, are described, and many useful tables are included in this section of the volume. Special chapters are devoted to the materials and prices for piles, and the various systems in use for general reinforced concrete are described and illustrated, although these are by no means complete; and this is also the case with the systems described in the chapter dealing with ordinary steel and concrete construction, as many important systems are omitted, and it would not have entailed very much time if these had been more complete.

The volume is well worth the price asked for it, and should prove very useful to those connected with the question of estimating for reinforced concrete work.

"Cassell's Reinforced Concrete." Edited by Bernard E. Jones.

London Cassell & Company, Ltd, La Belle Sauvage, E C 398 pp +xx, price 15/- net

Contents.—Introduction — What Reinforced Concrete Is—Historical Notes —Concrete—Materials, Proportions and Mixing — Steel-Stress Simply Explained—The Theory of Reinforced Concrete—The Erection of a Reinforced Concrete Building—Forms and Centerings—Systems Described—Architectural and Surface Treatment of Reinforced Concrete—Durability of Reinforced Concrete—Waterproofing Concrete—Specifications, Quantities, Measuring, Estimating and Pricing—Arches and Bridges—Examples

This new volume certainly deals with the subject of reinforced concrete in a manner unlike any other book that has been published in the country up to the present, as great attention has been paid to the practical side of the subject, and an endeavour made to produce a complete treatise that will be a guide to all those interested in the material, without assuming that the reader already possesses a certain amount of knowledge. The fact that various portions have been contributed by writers possessing a special knowledge of that portion of the subject with which they had to deal should naturally tend to produce a reliable volume, and we feel that the value of this book will be due in a great measure to this fact. The comparisons between plain concrete, steel and reinforced concrete are interesting, and these are given by means of diagrams and tables, which illustrate comparative sizes, weights and costs in a manner which give a good idea of the value of reinforced concrete as a structural material. Special mention must be made of the chapter on Forms and Centerings, which is illustrated with numerous excellent diagrams which cover almost every conceivable case that will occur in practice, from a small fence post to a tall chimney, and the whole of these are taken from actual examples, which enhances their value. The notes on the erection of a reinforced concrete building

describe the method of carrying out a large factory, and they cover the arrangements for dealing with the various materials on the site, the plant and tools to be used, and the method of procedure to be followed in the actual execution.

Owing to the extensive use of reinforced concrete at the present time, and to the necessity of obtaining tenders for this class of work on a fair basis, considerable attention is now being paid to the question of preparing quantities, and we are glad to see that a chapter is included on this portion of the subject, although this does not deal with the matter as fully as would be possible. The theoretical portion of the subject is dealt with in a very simple manner, every definition and symbol being explained as fully as possible, in order that the reader may be quite conversant with the elementary principles. The reader should experience no difficulty in following the various formulæ and calculations given, and more especially as the construction of the former are clearly shown step by step, and no knowledge of advanced mathematics is necessary.

The whole volume is written and presented in such a way that it should appeal to architects and students, who are often inclined to look upon the study of reinforced concrete as a matter involving a tremendous amount of time and a good knowledge of higher mathematics, and they are apt to avoid the subject and leave this method of construction to specialists without being in a position to check the calculations or prepare a specification. It should form an excellent book of reference for architects, and prove very useful to students preparing for examinations, and would, we consider, be a very good text-book for class purposes.

"Transactions and Notes of the Concrete Institute." Vol. IV., Part III.

Published at the Offices of the Institute, Denison House, 296 Vauxhall Bridge Road, Westminster, S.W.

This volume contains some notes as to the membership of the Institute, its library, and an account of various works and buildings visited. It also contains a paper, with illustrations, read by Reginald Ryves, Assoc.M.Inst.C.E., on "Calculations in the Design of a Thrust Buttress Masonry Dam," and a much belated one by Richard L. Humphrey, M.Inst.C.E., on "Fireproofing," read in 1911. These papers have already been amply reported in our journal.

Spon's "Architects' and Builders' Price Book and Diary."

Published by E. & F. Spon, Ltd., 57 Haymarket, S.W. Price 5/- net.

Spon's "Architects' and Builders' Price Book and Diary for 1913" is a most valuable reference book for all those connected in any way with the building trade. It maintains the high standard of former issues, and the prices, etc., have been thoroughly revised and brought up to date. The usual order of trades is adopted as in a well drawn-up bill of quantities, and there is also a fully detailed index to these trades.

Lockwood's "Builders' and Contractors Price Book for 1913."

Published by Crosby, Lockwood & Son, 7 Stationers' Hall, Ludgate Hill. Price 4/-.

This price book is published for the use of architects and surveyors and those connected with the building trade, and maintains its very high standard.

In this very useful handbook the first part deals with every class of building work, and the prices and wages tables have been carefully revised and brought thoroughly up to date. There is a section dealing exclusively with electric lighting, also a list of London district surveyors, and particulars of the boundaries of their districts to accord with the changes made by the London County Council, as well as a list of surveyors of the various metropolitan borough councils and their addresses.

In the appendices will be found tables of weights, areas, etc., solicitors' costs, stamp duties, tables for the valuation of leases and estates, legal notes and memoranda, and a great amount of other valuable information. A copy of the London Building Act, with its numerous amendments, is included.

"Foundations and Machinery Fixing." By Francis H. Davies, A.M.I.E.E.

London: Constable & Company, Ltd., 10 Orange Street, Leicester Square, W.C. 152 pp., price 2 · net.

Contents.—The Functions of Foundations, Nature of Soils and Piling—Trial Bores—Design of Foundations—Design—The Proportions of Foundations for Engines, Turbines, and Dynamo-Electric Machinery—Materials for Foundations—Holding-down Bolts and Anchor Plates—Excavation—Construction of Foundations—Vibration: Its Causes and

Effects — Vibration: Methods of Isolating Machinery—The Fixing of Electric Motors.

The question of the design and construction of proper foundations for machinery is one that is very often overlooked, and this despite the fact of the great trouble that often arises through excessive vibration, which tends to injure the machinery and create a nuisance to the occupiers of any adjacent buildings. The consideration of the most suitable foundation to adopt is undoubtedly the duty of every engineer who is connected with this type of work; but we agree with the author that it is a matter which also greatly concerns the architect, and co-operation between the two parties is essential. The author deals very thoroughly with the points to be considered in the design of the foundations for various types of machinery, and there are numerous useful tables and diagrams in the volume. The question of vibration is dealt with in a very interesting manner, and the examples given are sufficient to impress upon the reader the importance of making a study of this problem. Many remedies are given and various patent systems described, and there should be no difficulty in dealing with any type of machinery provided the matter is fully considered in the first instance. We have no hesitation in recommending this little book to our readers, who will find it both interesting and useful.

"Structural Design—Elements." By Horace R. Thayer.

London: Constable & Company, Ltd. 221 + vii pp, price 6/- net.

Contents. — Materials — Commercial Shapes—Wooden Structures—Fabrication of Structural Steel—The Engineering Department.

The author has assumed that the reader possesses a knowledge of mechanics, stresses, and mathematics sufficiently advanced to enable him to follow the formulæ, etc., without any detailed explanation of the elementary principles.

The greater portion of the book is devoted to the practical rather than the theoretical consideration of structural work, and it includes a full description of the fabrication of structural steel, together with notes on the organisation and administration in the shops and yards of the merchant. This portion is instructive, and contains a large amount of information seldom found in text books of this class, the examples described being all taken from American practice, as the author is engaged at the Carnegie Technical Schools at Pittsburg. The notes on materials include timber, cast iron, wrought iron, steel, alloys of steel, and paints, and although these are not very full or instructive in the chapter having this heading, there is a good description of the manufacture of the commercial shapes in the following chapter, which is clear and useful. There are a large number of pages allocated to the consideration of the procedure in the engineering department which covers the preparation of specifications, the designing of connections and members, the preparation of drawings, checking, examination of structures in use, and failures, and there are many useful hints and notes under these various sections.

It should prove a useful volume, and indicates a thoroughness on the part of the author which is commendable, and the various matters are presented in a clear and explicit manner.

POPULAR USES.

Under this heading it is proposed from time to time to present particulars of the more popular uses to which concrete and reinforced concrete can be put, as, for instance, in the construction of houses, cottages and farm buildings.—ED.

REINFORCED CONCRETE TENNIS COURTS.

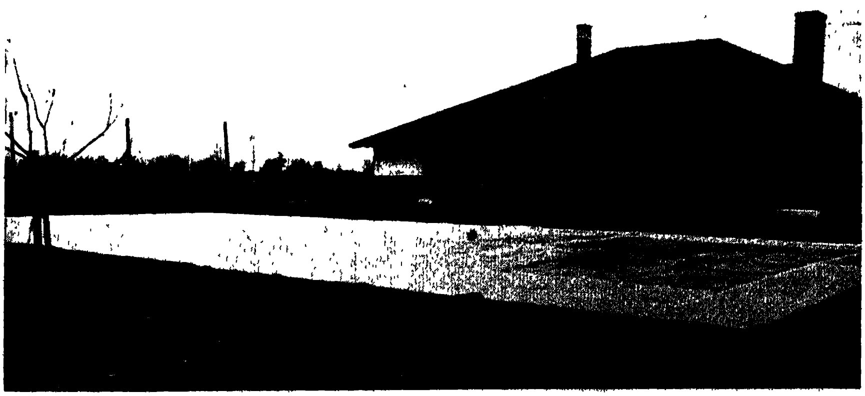
THE question of reinforced concrete for tennis courts has of late aroused considerable interest, and, in view of the increasing demand for hard courts which shall be available throughout the year, we present the following particulars as to how these courts were built in Northern Michigan, U.S.A. Our informant writes as follows:—

In building the concrete tennis court here illustrated, a sand foundation was utilised, as the nature of the land was nothing but sand. The court was built the regulation size, allowing 4 ft. on all sides for playing. It is 6 in. thick, reinforced with fence wire, the concrete being mixed about one to eight, and the facing a good mix, ¾ in. thick. Care was taken to put expansion joints through the entire thickness of the concrete. These were made with a sand joint in the rough concrete, and the facing was merely cut through with a trowel when it was nearly set so as not to be noticeable on the surface. Any cracks resulting from changes in the weather will naturally follow these joints and in no way be conspicuous. The principal reason for reinforcing this concrete was that the climate in northern Michigan is rather severe through the winter, which would subject the court to unusual strain. In an ordinary climate this would scarcely be necessary.

A pitch of 3 in. was made, the high point being in the centre at the net, and pitching back both ways. Drain tiles were set in along each side of the court and carried to a point of discharge.

The boundary lines of the court were constructed by putting in a wooden strip 1¾ in. wide, lined up perfectly true, and this is an important item, as an uneven line would be disastrous to the appearance of the court. After the top coat was finished these strips were removed and filled with white cement.

It was the intention to secure a green surface for the court, and to this end the best green colour was procured, but this caused great disappointment, as, owing to the chemical action between the colouring and the cement, it faded to the natural cement colour. A cement paint was then used, which gives the court a very nice



REINFORCED CONCRETE TENNIS COURT, MICHIGAN, U.S.A.

appearance, but, our informant states, it will not endure for more than a season, when it will have to be repainted.

It was endeavoured to find a guaranteed green colour for cement, but so far without success. It is very easy to get a brown colour, which serves the purpose just as well, but painting is not recommended as it only lasts a short time.

Care must be taken to get the court perfectly level, except in the direction of the pitch.

The court above described was built by Mr. F. H. Beaumont, contractor and builder of Cadillac, Michigan, and we are indebted to him for our particulars and illustrations.

REINFORCED CONCRETE TENNIS COURT, MICHIGAN, U.S.A.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Concrete Institute.—An interesting paper was read on February 13th at the Thirty-second General Meeting by Mr. S. Bylander, Chairman Junior Institution of Engineers, on "Steel Frame Buildings in London," of which a short report will be published in a subsequent issue.

The Concrete Institute have formed a special Investigation Committee for the purpose of considering the action of the Local Government Board in respect to loans for reinforced concrete construction, and the committee will be pleased to have any information which can be furnished upon the matter. Among other things, the committee is desirous of obtaining information as to specific cases in which the Local Government Board (*a*) have refused to grant a thirty years' loan period, (*b*) have granted the full period.

Scottish Junior Gas Association.—A paper on the "Construction of a Gasholder in a Reinforced Concrete Tank" was read in the course of the month by Mr. G. P. Mitchell, of Dundee. The paper referred to the increasing of the gasholder storage at the Alloa Gas Works by utilising a brick-built tank containing a single-lift holder of a capacity of 75,000 cu. ft., increasing the depth of the tank by constructing a wall of reinforced concrete, and erecting in it a three-lift holder equal in capacity to 280,000 cu. ft.

Apart from the necessity of increasing the storage capacity of the works, the single-lift holder had been constructed so that the pressure thrown was only 22-10ths. For several years the gasholder had been of almost no practical value, as the day pressure required to meet a largely increased demand for gas for engines and cookers is 30-10ths.

The old tank was brick built, having a puddle bottom. It was erected in the year 1862, and had proved watertight, and, generally speaking, was known to be in a satisfactory condition. The work of emptying the tank was completed in twenty-five hours.

On examining the tank it was found to be in splendid condition. As a precaution, however, it was decided to point the brickwork with cement; and after picking the joints, the walls were thoroughly washed with a pressure of water from a hose, preparatory to cementing, in order to clean out the joints.

The rest blocks had to be replaced by new ones, due to the difference in centres. They were made of cast iron and laid on a concrete foundation.

The required depth of the new tank being 20 ft. 9 in., it was necessary to raise the existing wall by 5 ft.; and consideration was given as to whether this should be brick built or reinforced concrete. It was ultimately decided to build a reinforced concrete circular wall to the required height. The reasons for adopting reinforced concrete instead of brick were as follows: (1) The relative lightness of the additional dead load superimposed on the old brick wall. (2) The superior watertightness of reinforced concrete over brick—more especially in this case, where the superimposed wall is not backed by clay, but is entirely above ground. (3) The reliability of reinforced concrete against the bursting pressure of the contained water.

The inside diameter of the tank wall is 81 ft. 11 in.; and the thickness of the reinforced concrete circular wall is 8 in.

Having stripped 15 in. off the coping of the old wall, a 4½-in. channel was cut out

in the centre of the brickwork—thus forming a groove and binding the old and new work together.

The standards of the gasholder are carried on ten reinforced concrete buttresses, equally spaced round the outer circumference of the tank; and the foundations of these buttresses were carried right down a considerable depth to a hard subsoil. In front of each buttress $4\frac{1}{2}$ in. of the brick wall of the tank were cut out so as to tie the concrete to the old brickwork. In each buttress a vertical bar was placed at each corner, and kept in position by $\frac{3}{8}$-in. diameter bars at 6-in. centres. The buttresses were brought up to the ground level before cementing to the wall. After the concrete had set, the space left was filled in with puddle, which was well watered and rammed in.

After excavating for the new 18-in. diameter inlet and outlet pipes, the concrete foundation for the drip-box was laid. A hole was cut through the wall to allow for the length of pipe; and a suitable concrete foundation was made inside the tank to receive the duck-foot bend. The drip-box, length of pipe, and duck-foot bend were then set in, connected together, and carefully tested. Concrete was packed round the drip-box and bend until the top of the pipe was covered, the wall being rebuilt and puddled inside and out.

The ground being cleared and levelled, the work of erecting the wall was started. The horizontal reinforcing bars of the reinforced concrete wall are carried into the buttresses; but the wall itself was sufficiently reinforced to resist the bursting pressure of the contained water without the aid of the buttresses. For this purpose the main tensional reinforcement is carried horizontally, and the sectional area of the bars is reduced from the bottom upwards in proportion to the pressures. All horizontal bars were overlapped 4 ft., and thoroughly anchored in the concrete at their ends by means of right-angle bends; and vertical bars were also placed, staggered at back and front of the wall, to distribute the stresses—the two sets of bars forming a complete grillage of steel in the concrete.

At the top of the reinforced concrete wall a gangway or platform 1 ft. 8 in. in breadth was formed right round the tank, projecting in cantilever form from the wall 1 ft. 8 in. This was also constructed in reinforced concrete 4 in. in thickness.

The total weight of steel reinforcement used in the reinforcement of the wall, gangway, buttresses, and their foundations was $6\frac{3}{4}$ tons. All steel used was ordinary commercial rounds.

The concrete used for the wall was made in the following proportions: Gravel, free from sand, and all to pass the $\frac{3}{4}$-in. ring, 27 cu. ft.; sand, $13\frac{1}{2}$ cu. ft.; Portland cement, $7\frac{1}{2}$ cwt. This gave a particularly close-grained and dense concrete; and the concrete was also thoroughly consolidated when in position between the centering boards by means of vigorous ramming. No waterproofing compounds were used in the concrete, nor was any rendering of the wall after completion done. But after the removal of the boarding the surfaces of the wall were brushed over with two separate coats of Portland cement grout, thoroughly well rubbed in. The reinforced concrete wall, since being brought into use, has been found watertight. This portion of the work has proved eminently satisfactory in respect of efficiency and economy in capital cost.

A Very Large Reinforced Concrete Column was tested in the Pittsburgh Laboratory of the U.S. Bureau of Standards on December 14th, 1912, before a delegation from the National Association of Cement Users, meeting that week in Pittsburgh. It is reported to be the largest reinforced concrete column ever loaded to destruction. It was a hooped column 16 ft. long, 30 in. in diameter, with a core diameter of 27 in., giving a total core area of 572·55 sq. in. The reinforcement consisted of seven longitudinal $1\frac{1}{16}$-in. round rods, a $\frac{1}{2}$-in. wire helix, with 3-in. pitch and thirty-one flat spirals of No. 5 wire of three turns spaced vertically 6 in. centre to centre. The column commenced to show signs of distress about 1,500 lb. per sq. in., core area, and failed at a total load of 1,800,000 lb., or about 3,100 lb. per sq. in., core area.—*Engineering News.*

Uruguay.—In order to facilitate the handling and storage of goods discharged from vessels at Uruguay, four large depôt sheds have just been inaugurated. Each shed measures 100 m. by 45 m., has two floors, and is solidly constructed of iron and reinforced concrete. A third floor can easily be added if required. The work was carried out under contract with the Government by the German General Building Co., Ltd.

Concrete Chimney of Interesting Design.—A concrete chimney recently erected at a steel plant near Hamburg has many interesting features besides its great height of 328 ft. Among these are its acid-resisting lining, made absolutely necessary because the purpose of the chimney is to carry away smelter-furnace gases; the special heat-resisting lining which extends from the top of the base to a height of 66 ft., and the massive nature of the chimney's base.

The chimney, which is round in shape, tapers from an outside diameter of 30 ft., at the base, to 11 ft., at the top, where the free opening is 9 ft. in diameter. Immediately below the chimney proper is an underground vault, 13 ft. in height, which serves as an inlet for the gases. This is octagonal in shape, 36 ft. in diameter, at the base, and 31 ft. in diameter, at the top, and rests on a concrete block 7 ft. thick and 42 ft. in diameter, which is in turn supported by 237 wooden piles, the space around and between which is filled in with concrete. The reinforcing of the chimney consists, in part, of forged-iron rings imbedded in the concrete at intervals of about 6 ft. throughout the entire height.

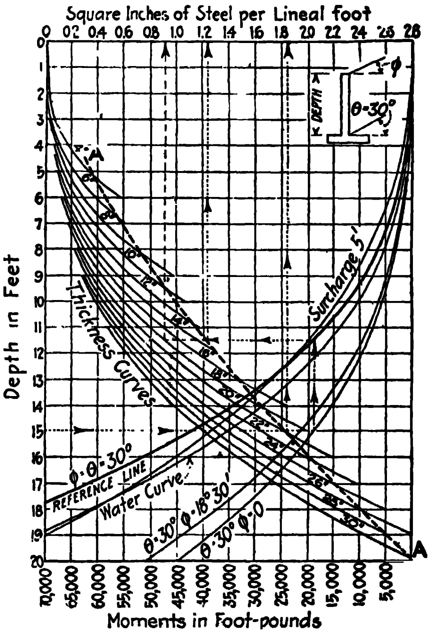


DIAGRAM FOR THE DESIGN OF THE VERTICAL SLAB IN CANTILEVER RETAINING WALLS.

Designing Diagram for Cantilever Reinforced Concrete Retaining Walls.—Mr. W. D. Hudson, of the Missouri-Pacific Railway Co., St. Louis, Mo., states he has found the accompanying diagram convenient in designing L-shaped reinforced concrete retaining walls. The purpose of the diagram is to ascertain quickly the proper thickness and reinforcement under different conditions of loading of the *vertical slab* in walls of the type shown in section on illustration. Its use may best be explained by means of examples traced out on the accompanying diagram.

Example 1.—To design the vertical slab at depth 15 ft. for a wall with surcharge angle of 30° and angle of repose 30°—*i.e.*, $D=15$, $\phi=30°$, $\theta=30°$.

At depth 15 on the left-hand ordinate, proceed horizontally to the heavy dashed line A—A, and read on the nearest "thickness curve" 20 in. Proceed thence vertically upward and read at top of diagram 1·84 sq. in. per lin. ft. for the amount of reinforcing.

In case any other thickness is required by other conditions, the reinforcing area is read in the same manner--thus, if 26-in. thickness is required, reinforcing area equals 1·4 sq. in. per lin. ft.

Example 2.—To design a slab at depth 15 ft. for a wall with level surcharge and 30° friction angle—*i.e.*, $D=15$, $\phi=0$, $\theta=30°$.

Where depth 15 intersects curve marked "$\theta=30°$, $\phi=0$," proceed vertically to curve marked "Reference Line," thence across to dashed line A—A, and read slab thickness 13½ in. Vertically above read reinforcement of 1·24 sq. in. per lin. ft.

The thicknesses of slab given are net thicknesses. Stresses used are: Tension in steel, 16,000 lb. per sq. in.; compression in concrete, 650 lb. per sq. in.; straight-line formula used in the analysis. As may be seen, the slab may be designed for five different conditions of loading.

It should be noted that the size of the base slab must be determined by some other means than given by this diagram.

For Any Slab.—The diagram can be used for *any slab* of known bending moment, as follows: Locate the bending moment on the scale at the foot of the diagram, follow upward to "Reference Line," and thence follow horizontally to the appropriate slab curve. Of course, where the horizontal meets the dashed line, the most economical thickness and reinforcement are found—*i.e.*, the design which realises the full allowed stresses in concrete and steel respectively.—*Engineering News.*

Lining a Deep Shaft with Concrete.—The 1,017-ft. Kingdon double-compartment shaft of the Old Dominion Company at Globe, Ariz., has been lined with concrete delivered from the surface through a 4-in. pipe. Work was started near the top and carried on in lifts from 150 to 220 ft. high. Temporary timbers were placed along the sides and ends and across the centre of the shaft at the bottom of each section and forms were built upon them. A permanent reinforced concrete bearer, 4 or 5 ft. high, was placed at the bottom of each lift. The forms were in 12-ft. sections and the concrete was made to run from a mixer at the top of the shaft into a hopper and down the shaft through the 4-in. pipe to the point where it was needed. At the lower end this pipe discharged into an ordinary steel bucket suspended from the finished portion of the lining above. In the side of the bucket was a hole connecting with a short steel chute which delivered the concrete directly into the forms. The *Engineering and Mining Journal* states that the concrete was dropped successfully in this manner for a distance of over 1,000 ft. in building the last section of lining.' The mixture was fed in regularly at the top and upper end of the pipe closed by placing a piece of canvas over the opening to stop the air current in the pipe and check the velocity of the concrete. The mixture was so dry that no water appeared upon the surface after being well worked. Had a wetter mixture been used the water would have separated from the sand and stone, taking the cement with it and leaving a lean concrete behind. The long walls of the lining were given a maximum thickness of 10 in. Old water pipes were cut into short lengths and placed in the concrete for weep holes through the wall. The concrete was a 1 : 3 : 6 mixture with the coarse aggregate varying from ½ to 1 in. in size. With twenty-five men working two shifts daily the time consumed in placing the lining was eight months, although the actual work of concreting was done in 100 days, or about 40 per cent. of the time consumed. Each of the two-shaft compartments is 5 by 7 ft. 2 in. inside the finished lining. The concrete lining, which was put in after the former wooden timbering had been destroyed by fire, gives 60 per cent. more shaft area.—*Engineering Record.*

TRADE NOTICES.

with inturned and twisted pieces embedded in the concrete. Full particulars of these doors can be obtained on application to Messrs. Chubb & Sons.

E. F. W. Grimshaw, The Reinforced Concrete Fence Posts, Ltd., have removed their office from West Mill, Buntingford, Herts, to 8, Broadway Court, Broadway, Westminster, London, S.W.

CATALOGUES RECEIVED.

Messrs. Ransome - verMehr Machinery Co. Ltd.—A new edition of this company's catalogue on concrete mixers has just reached us.

The book is not only well arranged and fully illustrated, but contains much that is of interest and use.

A full description is given of the various mixers supplied by the company and their applicability to almost any kind of work demonstrated by the quotation of examples where the mixers and storage plants are in use. It will be seen that these appliances are equally useful for bridge work, hoppers, railway work, tunnel construction, road work, etc.

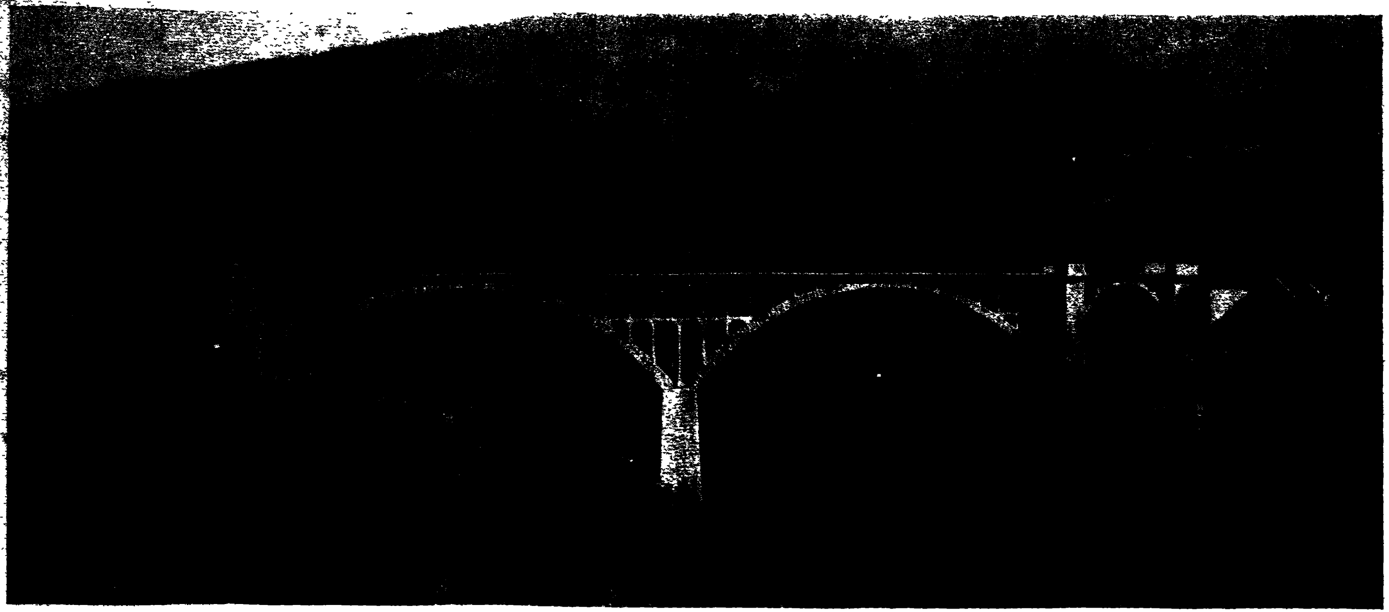
There is also a section of the book devoted to steel piling and pile extractors.

Copies of this catalogue can be obtained on application to the company at their address, Brunswick House, Westminster, London, S.W.

Trussed Concrete Steel Co. Ltd. — We have also received a copy of this company's new catalogue on their " Hy-Rib " system.

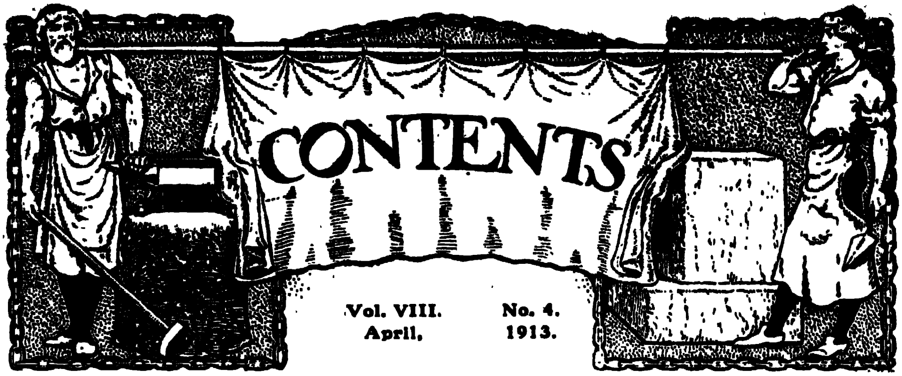
The advantages of the Hy-Rib and its varied application, together with a description of its method of manufacture, are dealt with at length and illustrated by means of diagrams and illustrations.

Specifications are given of how to apply Hy-Rib to walls, roofs, floors, ceilings and partitions, and the booklet concludes with an account of some tests to which this system of metal reinforcement was submitted. Copies of the catalogue are obtainable from the above-mentioned company at Caxton House, Westminster, London, S.W.



REINFORCED CONCRETE BRIDGE AT SEYTENEX, NFAR ANNECY, FRANCE.

(For description see *page* 280.)



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CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume VIII. No. 4. LONDON, APRIL, 1913.

EDITORIAL NOTES.

THE LOCAL GOVERNMENT BOARD AND REINFORCED CONCRETE.

It is quite a current subject in these columns to have to complain of the apathy, not to say prejudice, with which reinforced concrete is still being met at the Local Government Board's offices at Whitehall, and although we are quite prepared to say that there has been some slight improvement during the past few years, the fact still remains that an ordinary building of very poor construction is far more likely to be favourably considered than the best of buildings in reinforced concrete when a question of loan period is under review.

Efforts, both official, semi-official and private, have been made to obtain some change in the Local Government Board's attitude, but, with some few exceptions as to individual cases, the general principle still seems to prevail of looking upon reinforced concrete with grave suspicion.

We now assume, however, that some further effort is to be made to modify this unfortunate policy, which costs the ratepayer so dearly and makes the British Government a laughing stock among other civilised nations, who unwittingly attribute the inane conservatism of the Local Government Board to some grave matter of policy in the Government as a whole.

The Concrete Institute, as will have been seen in our previous issue, is, it would appear, trying to collect information as to loans refused by the Local Government Board and the terms upon which loans have been granted, and this looks like some fresh systematic effort to obtain a remedy based upon reliable data.

We would thus particularly recommend any public authority or professional man who has had experience of the Local Government Board's methods in this direction to immediately put themselves in communication with the Secretary of the Concrete Institute at Denison House, Vauxhall Bridge Road, Westminster, so that the Institute may have as full information as possible on this all-important subject.

BUILDING EXHIBITIONS AND REINFORCED CONCRETE.

In our March issue we gave some indication of the impending Exhibition at Leipzig, which is to be a Building Exhibition in the widest sense of that term, including architecture, science, construction, equipment and furnishing, and

having regard to the excellence of the organisation and the many interesting buildings in which the Exhibition is to be housed, the Leipzig undertaking certainly promises well.

As to the *rôle* to be played by reinforced concrete, it is a considerable one, both in the Exhibition structures and in the exhibits, and probably this Exhibition will mark, if we may say so, the advent of the new reinforced concrete age.

In London, too, we are to have our usual biennial Building Trades Exhibition at Olympia in April, which has a comprehensive display of the purely structural side of building, combined with exhibits of technical equipment, which is certainly unsurpassed anywhere and does its organisers great credit. Here, however, we regret to say reinforced concrete only plays a minor or secondary *rôle*, as the exhibits do not properly accord with the importance of the subject, and, in fact, we think that those concerned in reinforced concrete have been somewhat short-sighted in not arranging for more numerous and more extensive displays, in order to further their particular interests.

Reinforced concrete exhibits there will, of course, be at Olympia, but nothing like what we might have expected at a period when reinforced concrete is not only so much in the forefront of discussion, but when it has to make its way at home with the aid of what might generally be termed advertisement.

We view Building Exhibitions, such as the one at Olympia and the wider one at Leipzig, as eminently useful to the trades concerned and the public at large.

Just, however, as we anticipate that our Continental neighbours can take many a leaf from the book of the Building Trades Exhibition in London, so we also hope that we at home may be able to learn something from the Exhibition at Leipzig, and as this Leipzig Exhibition, as indicated above, will have exhibits that specially appeal to our readers interested in concrete and reinforced concrete, we would particularly remind those who are making plans for visiting the Continent during the current summer that a visit to Saxony may be both pleasurable and instructive.

MESSRS. HARRODS' DEPOSITORY, BARNES.

There are various points of particular interest in the building described in the following article, which was prepared for us by Mr. Albert Lakeman, Honours Medallist Construction.—ED.

THIS new building has been erected at Barnes for Messrs. Harrods, Ltd., from the designs of Mr. William G. Hunt, F.R.I.B.A., and the use of reinforced concrete in a structure of this kind is important and illustrates how universal the material is becoming for all classes of buildings. The great aim of the architect has been to evolve a scheme which would give the greatest safety to the many valuable articles of furniture that will necessarily be stored in the building, while at the same time necessitating only the minimum amount of handling of the articles and the maximum amount of accommodation. The building (illustrated in this article), the erection of which is just completed, is intended to eventually form the centre block of a very extensive range of depository buildings, and is considered to be the most up to date and efficient building of the kind in this country.

The principle of the construction may be described as that of a reinforced concrete frame building, all the constructional members being of this material, while the walls throughout are formed of 14-in. brick panels carried independently on the reinforced concrete frame, at each floor level. Similar interior division walls are used to subdivide the building into three portions, each of which is insulated from the others by means of fire lobbies having twin fire-resisting doors; thus rendering the spread of a fire from one division to another practically impossible.

It is interesting and important to note that the adoption of this method, together with the use of reinforced concrete for the constructional members, enabled the important matter of insurance against fire to be effected under Class I. B., which calls for the highest standard of perfection which is recognised by the insurance offices for buildings of this class, and a considerable saving in premiums is in consequence made by the proprietors and their clients. In fact, the insurance offices regard not only each storey, but *each of the three divisions* of each storey, as a separate risk, just the same as if each division were a separate building. A fact of this kind should be sufficient to convince even those few persons who are still sceptical as to the value of reinforced concrete as a fire-resistant, and make the material more popular with those building owners who are apt to look upon it as being still in the experimental stage.

The completed portion occupies an area approximately 125 ft. by 110 ft., and it has five storeys in all, giving a total height from the ground floor level to the main roof of about 66 ft. The four floors above the ground floor, and also the roof, are cantilevered beyond the general face of the building for a distance of

12 ft., and the pantechnicon furniture vans are driven directly on to a large electric lift, which is situated in the centre of the rear frontage, and are raised by this means to the floor required, the vans being then drawn off the lift, along the cantilevered balconies, to the most convenient point, and there unloaded direct from the van to the actual spot where the goods are to be stored. This is obviously a great advantage, as the possibility of damage to the article is considerably lessened, and several vans can be unloaded at the same time without any confusion or inconvenience arising. These cantilevers are quite a feature of the building, and they are illustrated in the exterior view which is depicted in *Fig.* 1, and they are described in detail in the subsequent notes.

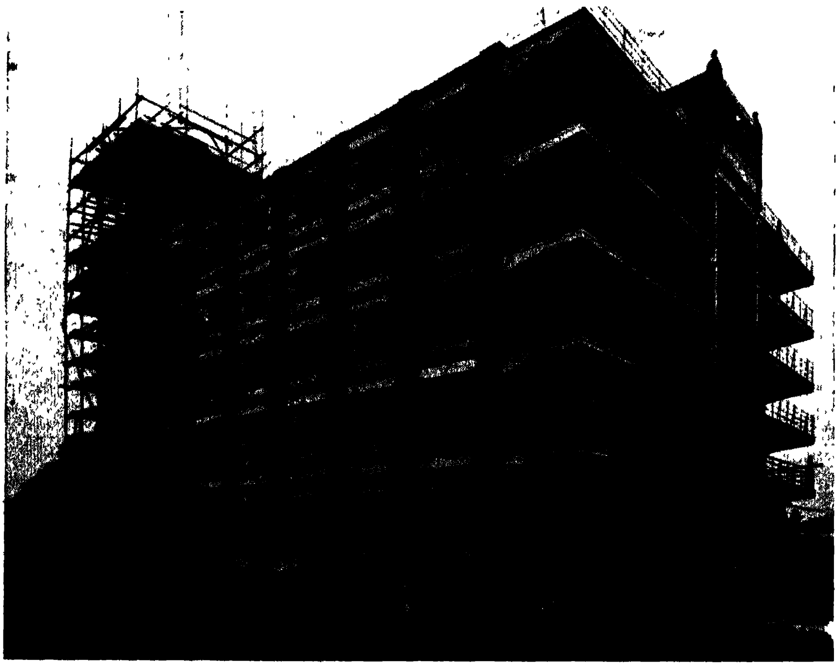


Fig. 1. Photographic View showing Cantilevered Balconies.
HARRODS' DEPOSITORY, BARNES.

The general arrangement of the constructional columns and beams is illustrated in the plan of the first floor in *Fig.* 2, there being fifty columns in all, and the details of the reinforcement, which were arranged by the Trussed Concrete Steel Co., will be found in *Figs.* 3, 4, 5 and 6. Some difficulty was experienced in the foundation work owing to the presence of water at a depth of 14 ft. below the surface, at which level a good Thames ballast was found. A large block of plain concrete was put in as a foundation for each column, the average size being 8 ft. 6 in. square, and on this the reinforced concrete base was commenced at a level of about 7 ft. below the ground floor. A typical detail is shown in *Fig.* 3, where it will be seen that this reinforced base consisted of a slab 5 ft. square, having a minimum thickness of 9 in. at the extreme outer

edges, splayed upward towards the column to give a maximum thickness of 18 in. at the intersection, to provide the requisite area for resisting shear. This slab is reinforced on the lower surface with six Kahn trussed bars in each direction, and four 1-in. Rib bars are provided as anchors between the column and the base. The column is continued from the base to the ground floor level as a square column, having a 3-ft. side reinforced with six lines of vertical reinforce-

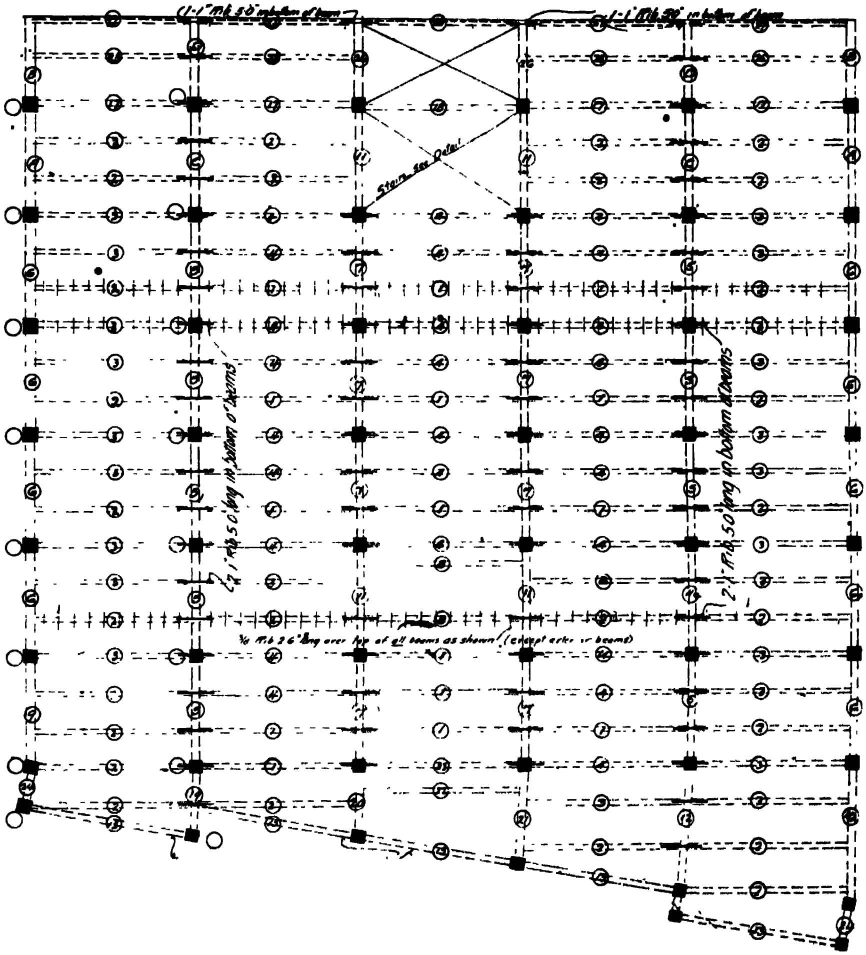


Fig. 2. General Plan of Columns and Beams.
Harrods' Depository, Barnes.

ment with spiral binding, and at this level it becomes circular for a height of 12 in. before being reduced to an octagonal section as shown. The circular portion is protected with an iron kerb and sheathing to prevent damage by the vans. The whole of the upper columns are octagonal in section, as shown in *Fig.* 4, which illustrates a typical detail, and it will be seen that six vertical lines of reinforcement are provided with spiral binding, giving a circular core. The binding is arranged to finish at the centre of the floor slab; and the end is bent 9 in. into the column and hooked. The size of the column illustrated is about 1 ft. 9 in.

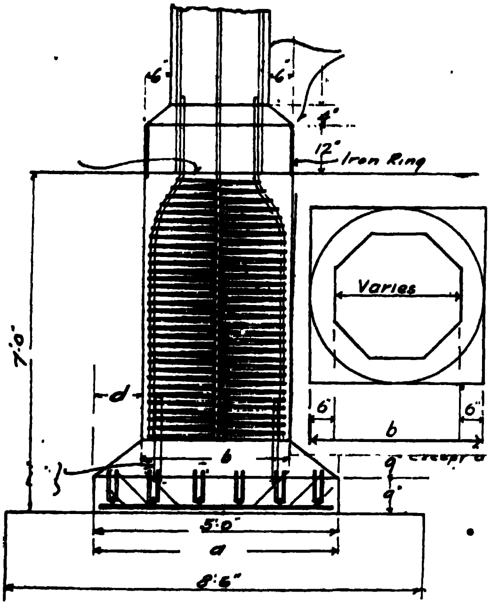


Fig. 3. Detail of Column and Base.
HARRODS' DEPOSITORY, BARNES.

for the lower portion and 1 ft. 6 in. for the upper part, these dimensions being taken between two opposite faces and at right angles to same.

The interior columns are spaced in six rows across the width of the building, giving a distance apart equal to about 22 ft. centre to centre, and in each of these rows they are spaced at about 14 ft. 6 in. centres. The floors are constructed with main and secondary beams, the former having a span of 14 ft. 6 in. and carrying the ends of two secondary beams on either side, the latter being arranged at intervals of 4 ft. 10½ in. These secondary beams are somewhat close together, but they required a depth of 18 in., as they span a distance of 22 ft. The width is 8 in., and the reinforcement consists of one Kahn bar and three Rib bars, as illustrated in *Fig.* 5, where the main beams are also shown, and it will be seen that these latter have a depth of 20 in. and a width of 13½ in., while they are reinforced for tension with one 1¼-in. Kahn bar, two 1⅛-in. Rib bars, two ⅞-in. Rib bars, and one 1-in. Rib bar

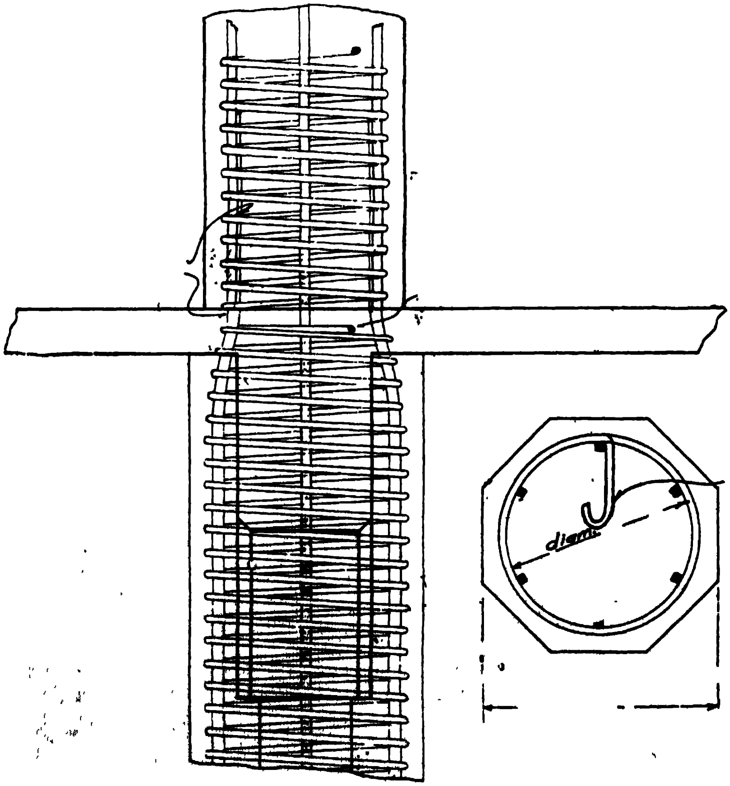


Fig. 4. Detail of Column.
HARRODS' DEPOSITORY, BARNES.

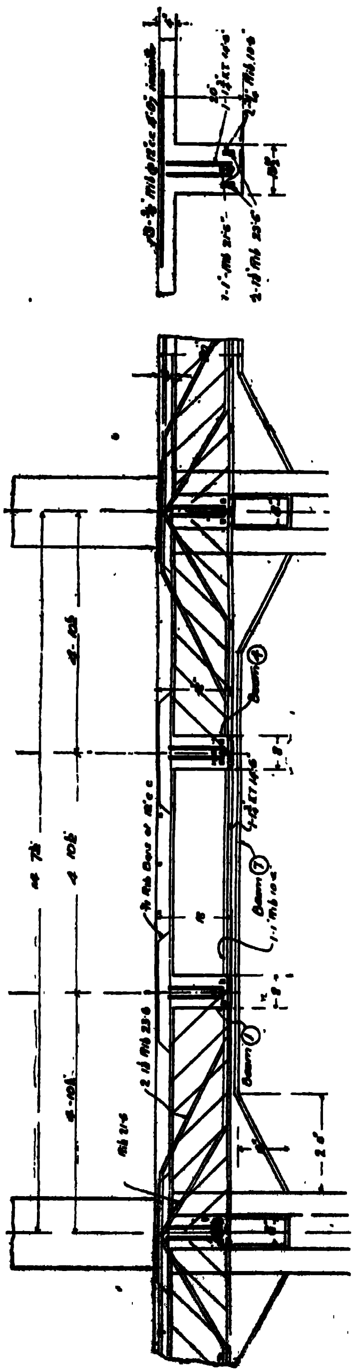


Fig. 5. Typical Detail of Floor Beams.
HARRODS' DEPOSITORY, BARNES.

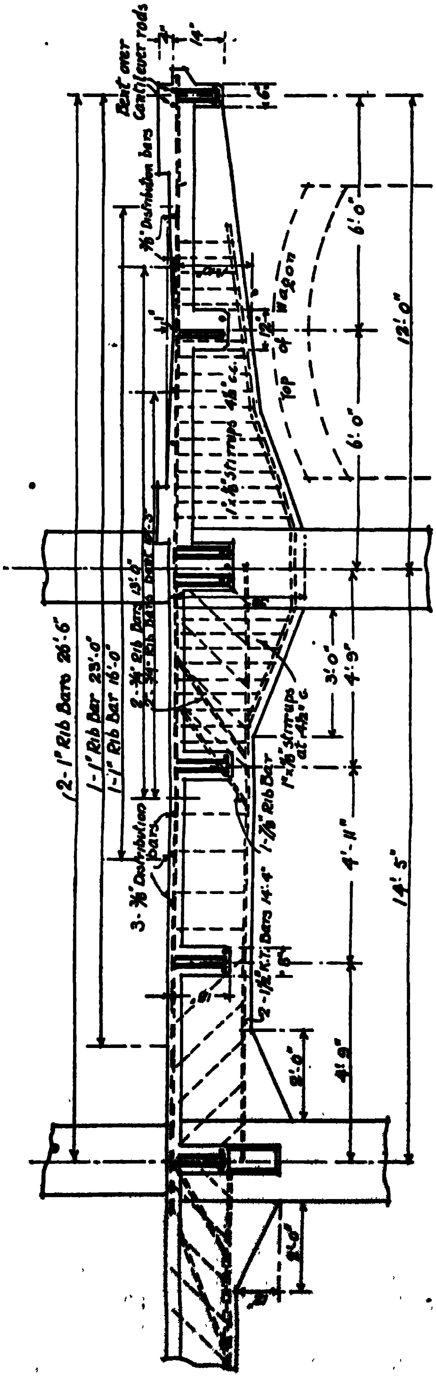


Fig. 6. Detail of Cantilever supporting Balcony.
HARRODS' DEPOSITORY, BARNES.

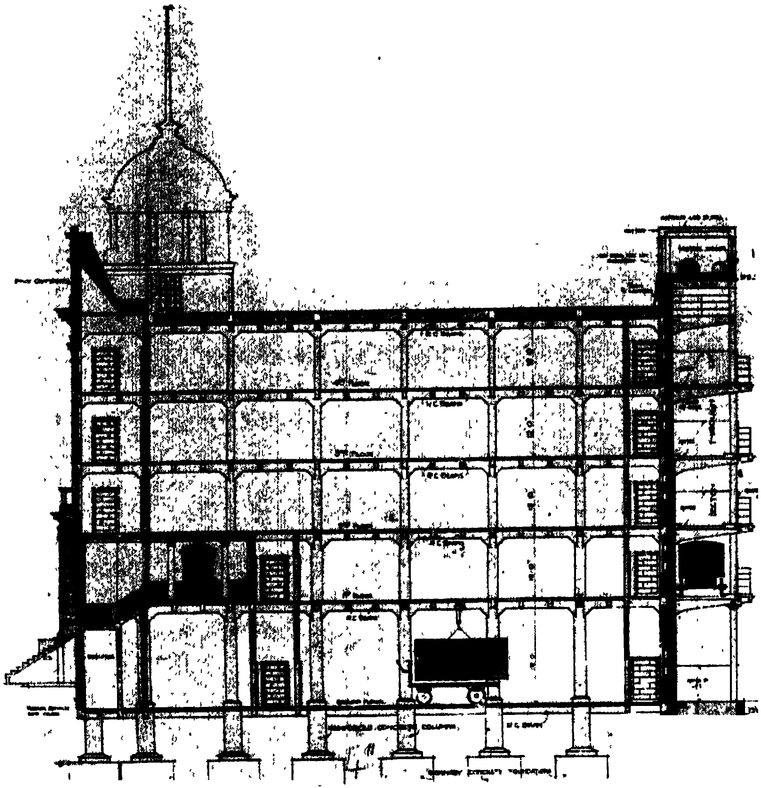


Fig. 7. Section of Building.

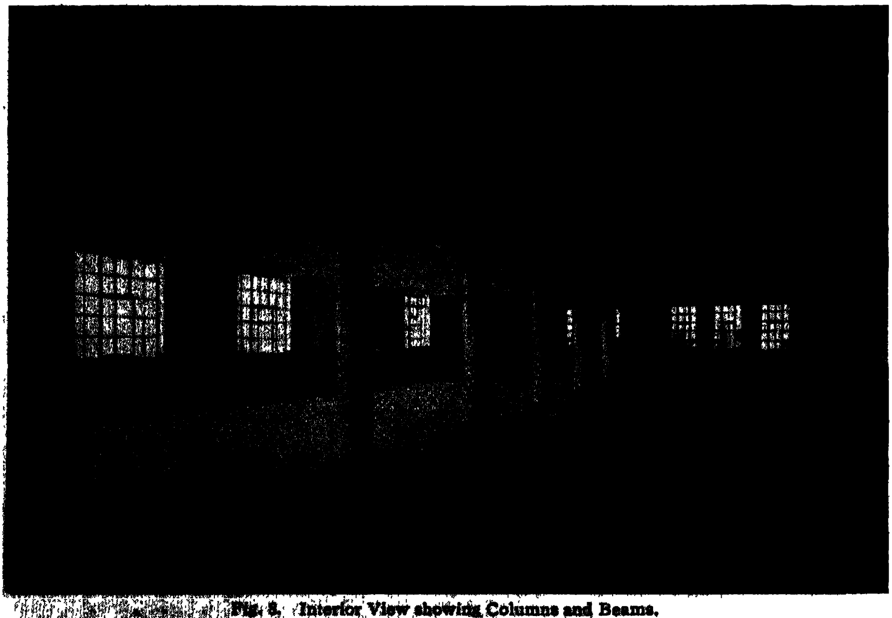


Fig. 8. Interior View showing Columns and Beams.
HARRODS' DEPOSITORY, BARNES.

Continuity bars, 4 ft. long, are placed at 12-in. centres in the upper surface of the slab, these being $\frac{3}{8}$-in. Rib bars, and similar bars, 2 ft. long,

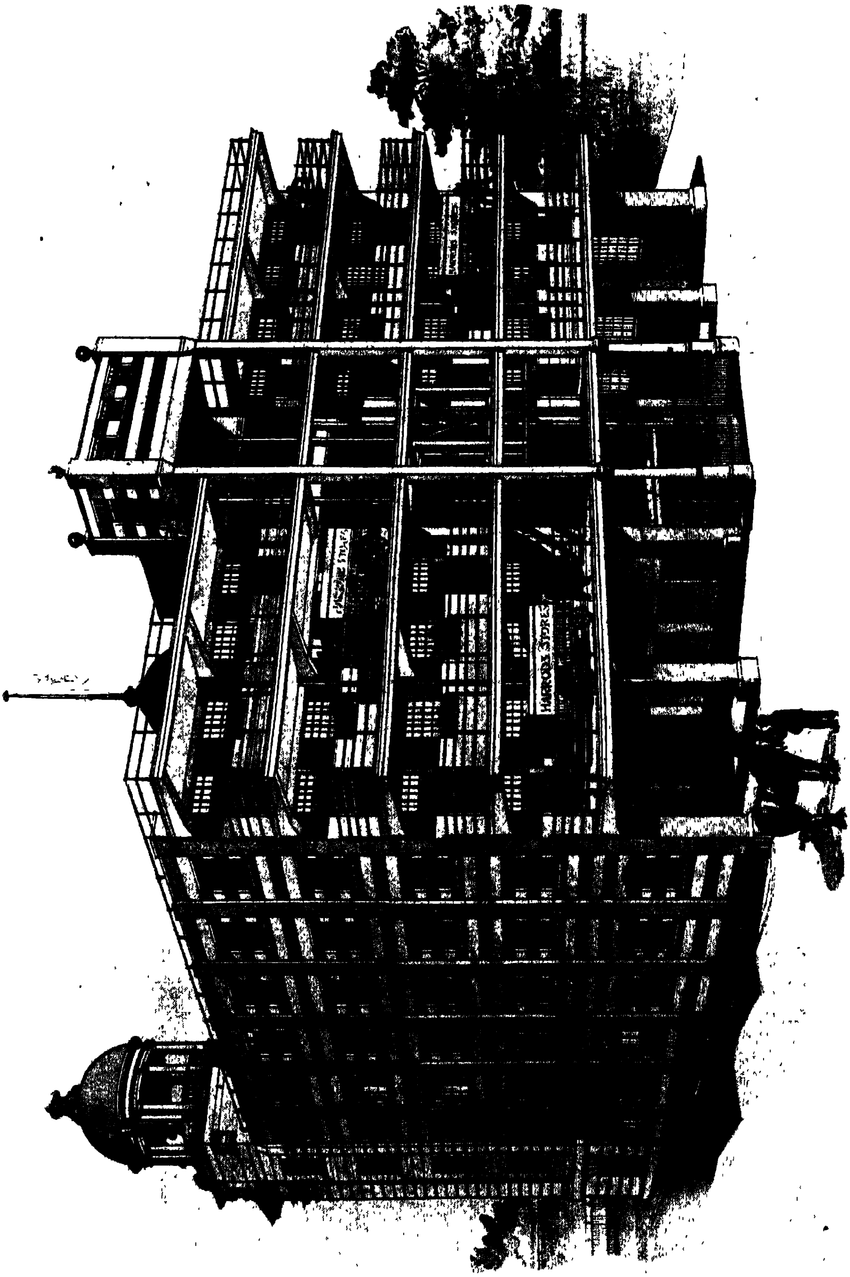


Fig. 9. Perspective View of Finished Building. Harrods' Depository, Barnes.

are provided over the secondary beams, while ample provision against shear is made as shown on the drawing in *Fig.* 5. It will be seen that all the beams

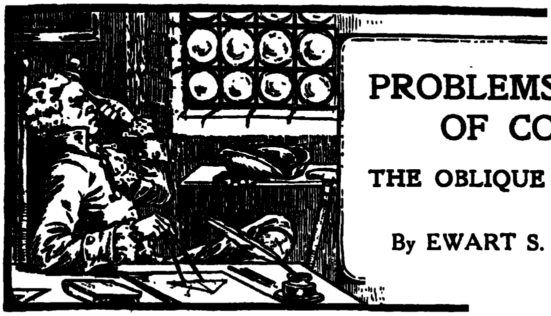
which are framed into the columns have brackets 2 ft. long and 12 in. deep, and the general appearance of the finished work is well illustrated in *Fig.* 8, which is a photographic view of the interior.

The floor slabs have a thickness of 4 in., and these are reinforced with ⅜-in. rib bars. The window lintels are continuous, and these form the beams for carrying the floor and wall above each opening.

The cantilevered balconies are shown in *Fig.* 7, which is a section through the building, and in *Fig.* 6, which is a detail drawing of this part of the work. These balconies are supported by six cantilevers at each floor level, which are provided by the continuation of the main floor beams at this point. The latter have, however, an increased section for the span immediately behind the cantilever, as this forms the tailing down portion from the front column, which acts as the fulcrum. The balconies have a projection of 12 in. from the centre line of the column, and the slab which actually forms the floor of the balcony is carried by three beams, the two outer ones spanning between the cantilevers, and the inner one being supported directly by the columns. The beam at the extreme outer edge has a depth of 18 in. and a width of 6 in., and is reinforced by Kahn and Rib bars, while the intermediate beam, which is formed midway between the columns and the outer beam, is 16 in. deep and 12 in. wide, with reinforcement as shown. The cantilevers have a minimum depth of 14 in. at the outer end, and this is increased to 1 ft. 10 in. at the centre of the projection and 3 ft. 2 in. at the junction with the column. Reinforcement is provided in the upper and lower surfaces, and stirrups are placed at 4½-in. centres. The tailing down beam is also reinforced in the upper and lower surfaces, and similar stirrups are provided in the portion adjacent to the column. The floor of the balcony has a slight fall from either side toward the centre, and raised concrete curbs are formed to confine the wheels of the vans. The arrangement is admirably carried out, and the adoption of reinforced concrete for the cantilevers and balconies undoubtedly permitted the most suitable and economical form of construction to be executed.

The building is effectively designed with terra-cotta dressings and facing to the front elevation, while the introduction of a cupola at the corners of the main front lends additional interest and gives a good sky-line. The weight-carrying members in these features are all constructed of reinforced concrete, thus giving a complete concrete frame to the whole building.

The general contractors for the work were Messrs. Holland and Hannen, of Bloomsbury.



PROBLEMS IN THE THEORY OF CONSTRUCTION.

THE OBLIQUE LOADING OF BEAMS AND COLUMNS.

By EWART S. ANDREWS, B.Sc.Eng. (Lond.).

The following article should be of interest to engineers who, in the course of their practice, must often have to deal with the question of the oblique loading of beams and columns.—ED.

CALCULATIONS arise occasionally in the practical design of beams and columns in which oblique loading has to be allowed for. By oblique loading we mean "loading whose plane does not contain a principal axis of the section," and where this occurs we cannot obtain the stresses by the ordinary bending formulæ. In the case of columns, in which the point most commonly arises, "oblique loading" is a special case of "eccentric loading" and arises where the resultant load is eccentric and does not act down one of the lines of symmetry of the column.

The principal difficulty is on account of the fact that the neutral axis for oblique loading will not be at right angles to the plane of loading. We will deduce the formula that can be employed for this case and will then explain its use with reference to the case of an obliquely loaded column.

DERIVATION OF FORMULÆ.

Let *Fig.* 1 represent any section of a column or beam of which XX and YY are the ***principal axes***. The principal axes of a section are those passing through the centroid at right angles to each other about which the moments of inertia are greatest and least respectively. If the section has an axis of symmetry, this axis will be a principal axis and the other principal axis will be at right angles to it. We will show later how to find the principal axes of sections which have no axis of symmetry.

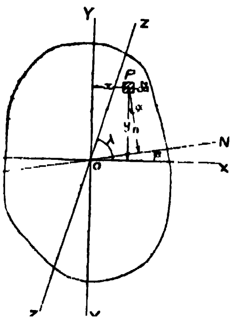


FIG. 1.

Let ZZ be the ***"plane of loading,"*** or rather the intersection of this plane with the section. In the case of ordinary beams, for instance, the forces would all be in the direction ZZ, and in the case of columns the resultant load will act at some point on ZZ.

NN is the neutral axis of the section, which will in this case not be at right angles to ZZ, but at some angle to XX.

Now consider an element of area a at a point P at distances x, y, n from XX, YY and NN respectively. (In the position shown these quantities will, according to the usual convention, be positive.)

Then we shall have, since the stresses are always proportional to the distance from the neutral axis, f = stress at $P = mn$ where m is a constant.

Now if M is the bending moment, its components about XX and YY must be equal to the sum of the moments of the stresses on the section about these axes.

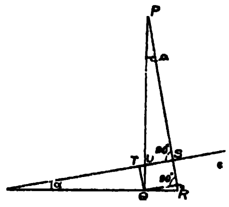


FIG. 2.

$$\therefore M \sin\lambda = \text{component of } M \text{ about } XX = \Sigma f \,.\, \delta a \,.\, y$$
$$= \Sigma\, mn\, y\delta a \qquad (1)$$

but $n = y \cos a - x \sin a$ (2)

[This can be seen from *Fig.* 2, which shows this part of the diagram redrawn to avoid confusion. $PS = n$, $PQ = y$, $OQ = x$. PQ and PR make an angle a with each other. QR is drawn parallel to US and QT at right angles to ON.

Then $y \cos a - x \sin a = PR - QT = PR - SR = PS$.]

$$\therefore M \sin\lambda = \Sigma m\, (y^2 \cos a - xy \sin a)\, \delta a$$
$$= m \cos a \Sigma y^2 \delta a - m \sin a \Sigma xy\delta a \qquad (3)$$

now $\Sigma xy\delta a$ is what is called the *product moment* of the section and this is always zero for the principal axes; also $\Sigma y^2\delta a = I_{XX}$.

$$\therefore M \sin\lambda = m \cos a\, I_{XX} \qquad (4)$$

Similarly
$$M \cos\lambda = \text{component of } M \text{ about } YY$$
$$= \Sigma f \,.\, \delta a \,.\, x$$
$$= \Sigma mnx \,.\, \delta a$$
$$= \Sigma m\, (y \cos a - x \sin a)\, x\delta a$$
$$= m \cos a \Sigma xy\delta a - m \sin \delta \Sigma x^2 \delta a$$
$$= O - m \sin a I_{YY} \qquad (5)$$

Dividing (4) by (5) we get

$$\tan\lambda = \frac{-\cot a \,.\, I_{XX}}{I_{YY}}$$

$$\cot a = \frac{-I_{YY} \tan\lambda}{I_{XX}} \qquad (6)$$

This equation enables us to obtain the neutral axis. To get the stress at P in its most convenient form we can proceed as follows:—

From (4) and (5) we get

$$m = \frac{M \sin\lambda}{I_{XX} \cos a} = \frac{-M \cos\lambda}{I_{YY} \sin a}$$

$$\text{Now } f = mn = m\,(y \cos a - x \sin a)$$
$$= my \cos a - mx \sin a$$
$$= \frac{M \sin\lambda y \cos a}{I_{XX} \cos a} - \left(\frac{-M \cos\lambda x \sin a}{I_{YY} \sin a}\right)$$
$$= \frac{M \sin\lambda \,.\, y}{I_{XX}} + \frac{M \cos\lambda \,.\, x}{I_{YY}} \qquad (7)$$

Since this formula does not involve a, the actual position of the neutral axis is not required for the calculation of the stress at any point, but it is usually better to find the neutral axis, because the values of x and y required to

find the maximum stress will be those for the point at maximum distance from the neutral axis, and this cannot always be found until the neutral axis is drawn in. An example of an obliquely loaded beam arises in the case of the cross beams of a bridge inclined to the horizontal, the cross beams being fixed "square" to the main girders.

In applying this treatment to obliquely loaded columns, it should be remembered that the value of f above is that due to bending only, and this must be added to the direct stress per square inch equal to the load divided by the area.

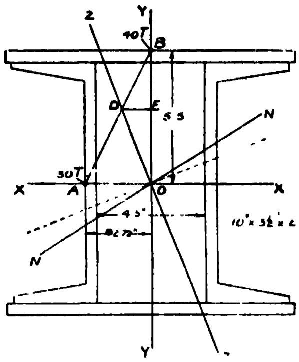


FIG. 3.

NUMERICAL EXAMPLE OF AN OBLIQUELY LOADED COLUMN.

Take, for instance, a column of the section shown in *Fig.* 3. This is a corner column, 15 ft. long, and has loads transmitted to it at A and B of 30 and 40 tons respectively, the resultant of which is a load of 70 tons acting at D. We shall see later that this gives a very simple result.

The following properties of this section are given in Dorman, Long and Co.'s *Pocket Companion* :—

$$A = 28{\cdot}59 \text{ sq. in.}$$
$$k_{XX} = 4{\cdot}45 \text{ in.}$$
$$k_{YY} = 3{\cdot}39 \text{ in.}$$

$$D \text{ will divide } A\,B \text{ in the ratio } \frac{AD}{DB} = \frac{4}{3}$$

$$\text{Measurement gives } \lambda = 110{\cdot}4^\circ$$
$$\therefore \tan\lambda = -2{\cdot}69$$
$$\cot\alpha \text{ [from equation 6]} = -\frac{28{\cdot}59 \times 3{\cdot}39^2\,(-2{\cdot}69)}{28{\cdot}59 \times 4{\cdot}45^2} \quad [\text{Since } I = Ak^2]$$
$$= \frac{3{\cdot}39^2}{4{\cdot}45^2} \times 2{\cdot}69$$
$$= 1{\cdot}56 \text{ approx.}$$
$$\therefore \alpha = 32{\cdot}6^\circ \text{ nearly}$$

The neutral axis comes, therefore, as shown NN in the figure; the line at right angles, which would be the neutral axis if the ordinary treatment applied to oblique loading, being shown in dotted lines.

[We could calculate $\tan\lambda$ by noting that $\tan\lambda = \frac{EO}{ED} = \frac{4}{3} \times \frac{5{\cdot}55}{2{\cdot}72} = 2{\cdot}69$]

$$M \sin\lambda \text{ will be equal to } 70 \times OD \sin\lambda = 70 \times EO = 70 \times \frac{4 \times 5{\cdot}5}{7} = 220 \text{ in.-tons}$$

[This is the same as $40 \times OB$]

$$M \cos\lambda = 70 \times OD \cos\lambda = -70 \times DE = 70 \times \tfrac{4}{7} \times 2{\cdot}72 = -81{\cdot}6 \text{ in.-tons}$$

[This is the same as $30 \times OA$]

The maximum stress will occur at the top left-hand corner, for which $y=5{\cdot}5$ in., $x=-6$ in.

$$\therefore \text{Maximum bending stress} = f = \frac{220\times 5{\cdot}5}{28{\cdot}59\times 4{\cdot}45^2}+\frac{81{\cdot}6\times 6}{28{\cdot}59\times 3{\cdot}39^2}$$

$$=2{\cdot}14+1{\cdot}49$$

$$=3{\cdot}63 \text{ tons per sq. in.}$$

$$\text{Direct stress} = \frac{70}{28{\cdot}59} = 2{\cdot}45 \text{ tons per sq. in.}$$

$$\therefore \text{Combined stress} = 6{\cdot}08 \text{ tons per sq. in.}$$

Taking the safe stress by Rankine's formula

$$f_P = \frac{6}{1+6000\left(\frac{l}{k}\right)^2}$$

$$\text{we get } f_P = \frac{6}{1+\dfrac{15\times 12\times 15\times 12}{6000\times 3{\cdot}39^2}} = 4{\cdot}08 \text{ tons per sq. in. approx.}$$

On the above figures, therefore, the section is not quite strong enough.

SIMPLIFIED TREATMENT.

At the beginning of this example we remarked that it gave a simple result, the reason being that in this example the loads are applied on the principal axes. This will be seen by noting the facts that the $M\sin\lambda$ and $M\cos\lambda$ come equal to the *B.Ms* for the two loads considered separately and that the formula for f then comes equal to the sum of the bending stresses for the two loads considered separately by the ordinary formulæ with XX and YY as neutral axes. We get, therefore, the following simple rule for a column obliquely loaded when the loads are applied on the principal axes:—*Calculate the bending stresses for each load separately and add both these to the direct stress; then the result should not be more than the safe central stress for the given column according to the standard column formula.*

EQUIVALENT CENTRAL LOAD.

The most convenient way of dealing with the eccentric loading when a table of safe central loads for various column formulæ is available is to find the equivalent central load.

This may be done in the present case as follows:—Let W_Y and W_X be the loads applied on the axes YY and XX respectively, then equivalent central load

$$=W_1=W_Y\left(1+\frac{e_y\cdot y}{k_{XX}^2}\right)+W_X\left(1+\frac{e_x\cdot x}{k_{YY}^2}\right)$$

Where e_y, e_x are the eccentricities of W_Y and W_X and y, x are the distances of the furthermost points of the section from XX and YY respectively.

$$\therefore \text{In this case } W_1=40\left(1+\frac{5{\cdot}5\times 5{\cdot}5}{4{\cdot}45^2}\right)+30\left(1+\frac{2{\cdot}72\times 6}{3{\cdot}39^2}\right)$$

$$=40\times 2{\cdot}52 \qquad +30\times 2{\cdot}42$$

$$=174 \text{ tons nearly.}$$

Assuming that the present case is equivalent to both ends rounded (as we

have done in Rankine's formula), the equivalent length according to Messrs. Dorman, Long and Co.'s treatment is $\frac{15 \times 4}{3} = 20$ ft. Their tabulated safe central load for this section, 20 ft. long, is 145 tons, so that on their figures also the section taken is too small for the loads taken.

DETERMINATION OF PRINCIPAL AXES.

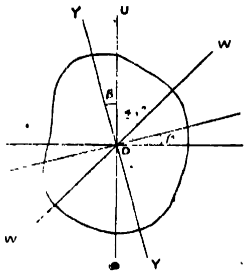


Fig. 4.

We stated earlier in the article that we would indicate how to calculate the position of the principal axes for a section with no axis of symmetry.

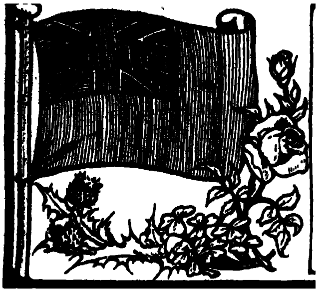
Let *Fig.* 4 represent any such section.

Take any two convenient axes, *UU* and *VV*, at right angles to each other, and also a third axis, *WW*, at 45 deg. to either.

Calculate (graphically or otherwise) the Moments of Inertia $I_{UU}\ I_{VV}\ I_{WW}$ about these axes. Then the inclination β of the principal axes to *UU* and *VV* is given by

$$\text{Tan } 2\beta = \frac{I_{UU} + I_{VV} - 2I_{WW}}{I_{UU} - I_{VV}}.$$

The angle β is given in the tables of standard sections for *Z* and unequal *L* sections, which are the only non-symmetrical sections which occur.



SOME RECENT EXAMPLES OF REINFORCED CONCRETE CONSTRUCTION IN SOUTH AFRICA.

In a former issue we presented a description of the use of reinforced concrete in South Africa, and in continuation thereof we now give the following particulars of some work carried out by Mr. Edmund D. Pickford, of Johannesburg, who has prepared these notes and furnished us with the illustrations.—ED.

THE chief difficulties which militate against the more general use of reinforced concrete in South Africa, more particularly in Johannesburg and inland towns, states Mr. Pickford, are the heavy cost of cement, labour and timber.

The price of cement, for instance, varies from 31s. 6d. per cask in Johannesburg to as much as 55s. in some of the chief towns in Rhodesia.

This heavy cost is largely due to railway charges.

The price of labour, too, bears more heavily than that of cement on the cost of reinforced concrete construction.

The standard rate of wages for carpenters in Johannesburg is 20s. per day, while it varies from 25s. to 30s. in parts of Rhodesia.

The mixing and laying of concrete is, of course, done by coloured labour, either Cape Boys or Kaffirs, who are paid in Johannesburg about 3s. a day; and although this is less than the wages of the English labourer, as one has, as a rule, to break in a fresh gang of concrete mixers for each job, and to pay for white superintendence, the cost of mixing and laying may be reckoned as at least equal to that in England.

Even, as along the East Coast, where one pays as little as 1s. a day for native labour, the result is much the same, as the labour is less efficient and the necessary superintendence costs more.

Labour-saving machinery is not economical, except in very few instances, as it involves white attendance, and the cost of transport and repairs at places away from towns is very heavy.

Timber works out roughly at about twice the cost of that in England, and as most jobs are not conveniently placed alongside the timber yards, sometimes being two or three days' trek by ox-wagon from the railway, it is necessary to calculate one's requirements in this direction very exactly, otherwise expensive delays are entailed.

Further, in a new country, especially in the mining centres, it is not the material which lasts longest or is most efficient that appeals to the employer's mind, but that which costs least; therefore reinforced concrete has to compete against steel construction, which has been brought by competition to great

economy and efficiency, and against brickwork, the prices for which are fairly low throughout the country.

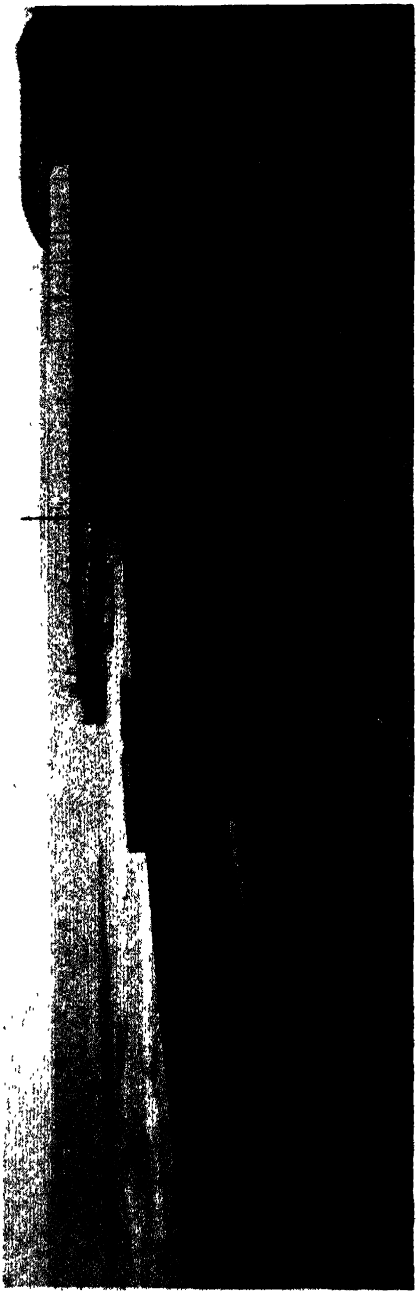
However, despite these drawbacks, a fair amount of work has already been done in the country, and there is no doubt that, with some competition in the

SWIMMING BATH, DURBAN, IN COURSE OF CONSTRUCTION.

manufacture, and a consequent reduction in price, of cement, the amount of work would be vastly increased.

Swimming Bath, Durban.

This bath is situated on the ocean beach just above high-water mark, and is 300 ft. long and 75 ft. wide, and is therefore one of the largest in the world.



Swimming Bath, Durban.

It was designed by Mr. John Fletcher, M. Inst. C. E., the Borough Engineer.

The bottom is 9 in. thick with ribs at 10 ft. intervals reinforced as beams, and the sides are 9 in. thick at the bottom, and taper to 6 in. at the top and are strengthened with counterforts above the ribs. The reinforcement consists of indented bars and a steel netting.

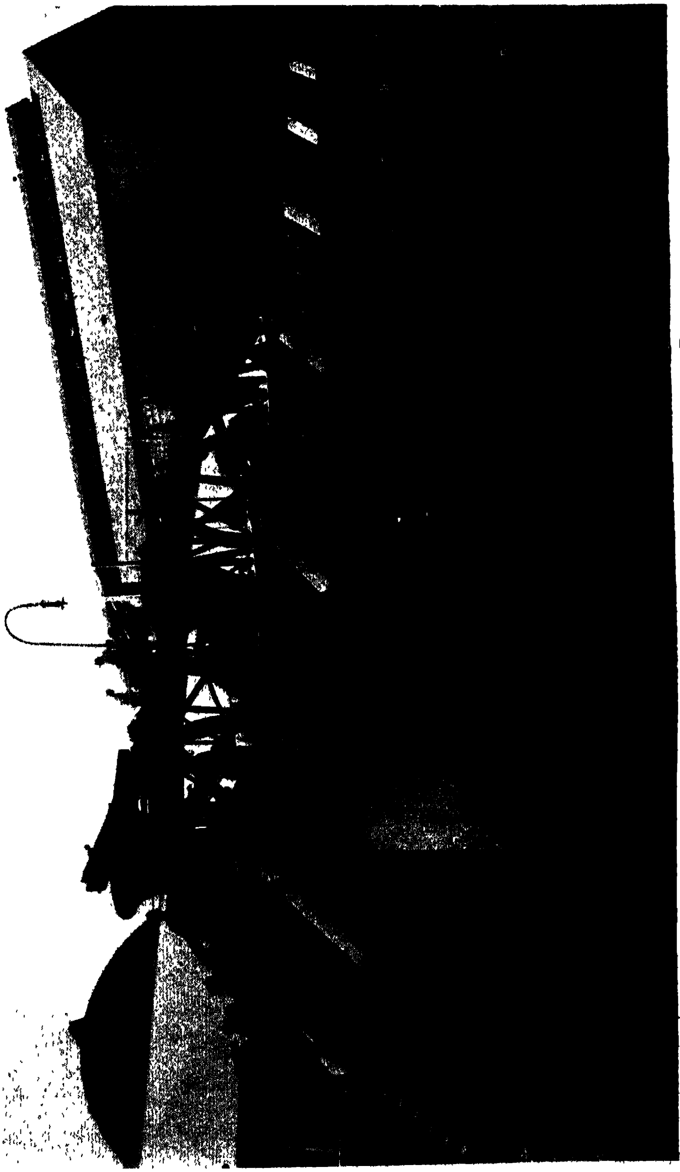
The work to the bottom was carried out continuously day and night, and, despite flooding by an unusually high tide, the whole of the excavation and reinforced concrete work was completed in about nine weeks.

Tube Mills Supports, Village Deep Gold Mine.

This is one of the largest and most complete installations of tube mills on the Rand, consisting of six mills, each about 35 ft. long and 5 ft. diameter. As the tube mills each weigh about 30 tons and make 35 revolutions per minute it will be understood that a considerable mass of concrete would be required to withstand the vibration. As a matter of fact, this is scarcely noticeable even with all mills running.

The reinforced concrete main beams have a span of 25 ft. and carry a platform calculated for a super load of 500 lb. per sq. ft. The reinforcement consists of mild steel rods, arranged on the Smith Pickford patent system.

The same type of construction was adopted at the Jumpers Deep Gold Mine, but in this case the height of the platform above ground was 13 ft. instead of 10 ft., and there were only three mills.



Tube Mill Supports. Village Deep Gold Mine, on the Rand.

Premier Milling Co. Premises, Germiston, Johannesburg.

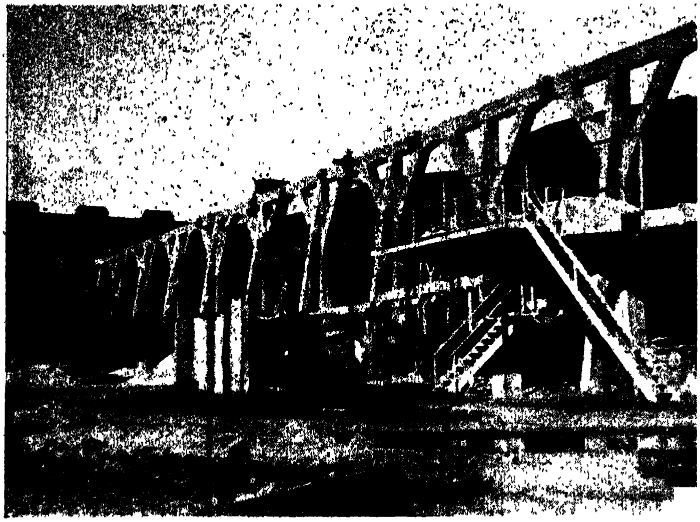
This building is constructed entirely of reinforced concrete, the walls being 6 in. thick with 18 in. piers and wall beams, which carry the weight of the floors and machinery, on the same principle as a steel-framed building.

The centre portion of the building contains twelve silos for the storage of mealies, each 6 ft. square and 45 ft. high.

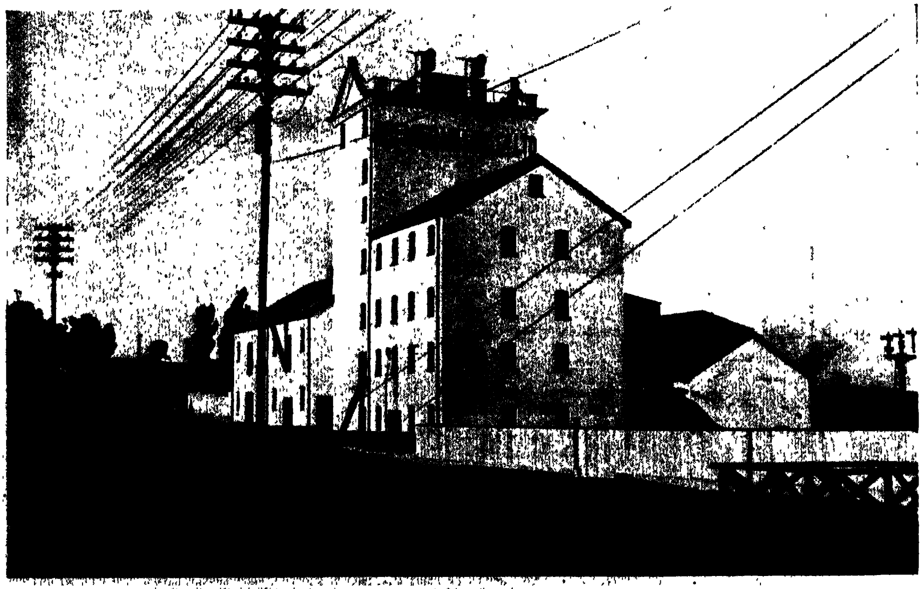
The reinforcement throughout consists of plain mild steel rods on the same system as the last.

Travelling Excavator Supports, Crown Mines.

These supports, which are about 30 ft. in height, carry a travelling excavator which weighs over 40 tons and has arms 25 ft. in length fitted with discs which rotate within the tanks ploughing up the sand. These arms each weigh about 2 tons and are driven at from 30 to 45 revolutions per minute, and as in their rotation



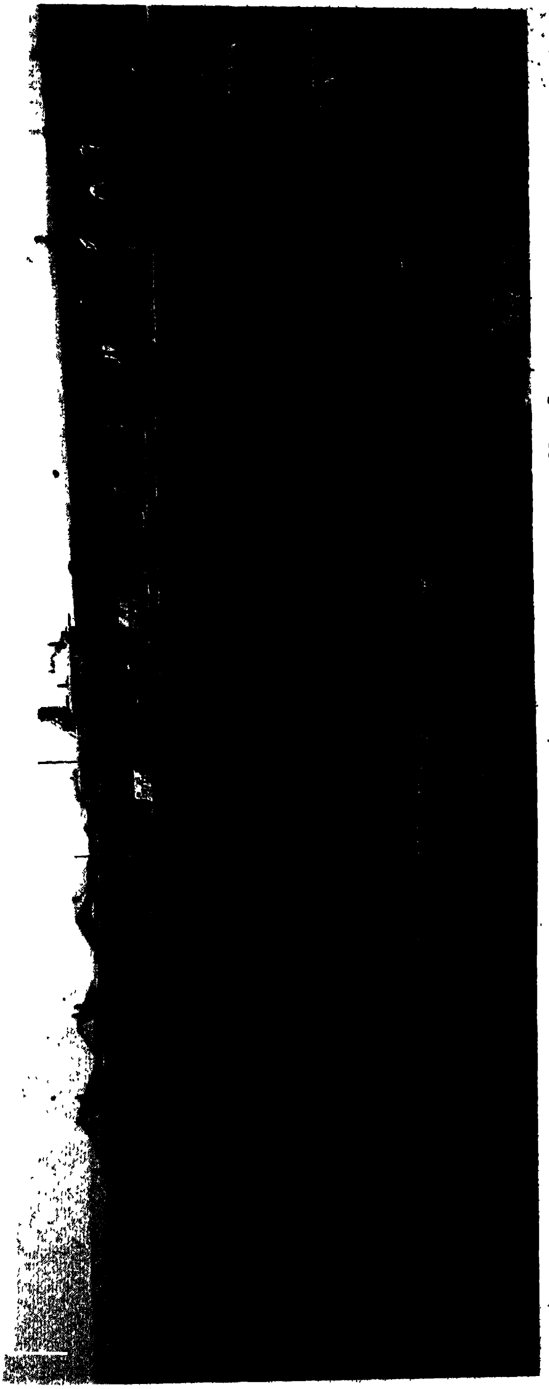
TRAVELLING EXCAVATOR SUPPORTS, CROWN MINES.



PREMISES FOR THE PREMIER MILLING CO., GERMISTON, JOHANNESBURG.

they encounter both sand and slime the strain on the supports is of a most trying description.

The length of the supports is 250 ft. and the distance between rails is 47 ft.



Reinforced Concrete Ore Bins, Randfontein Central Gold Mine Co.

There are two tracks with a connecting turntable, also constructed in reinforced concrete.

The reinforcement consists of round steel bars from ½ in. to 1⅛ in. in dia., and the uprights and beams were cased up and cast *in situ*.

The same design was adopted at the City Deep Mine, where the miners carried out the work themselves, but in this case the uprights were cast on the ground and raised into position.

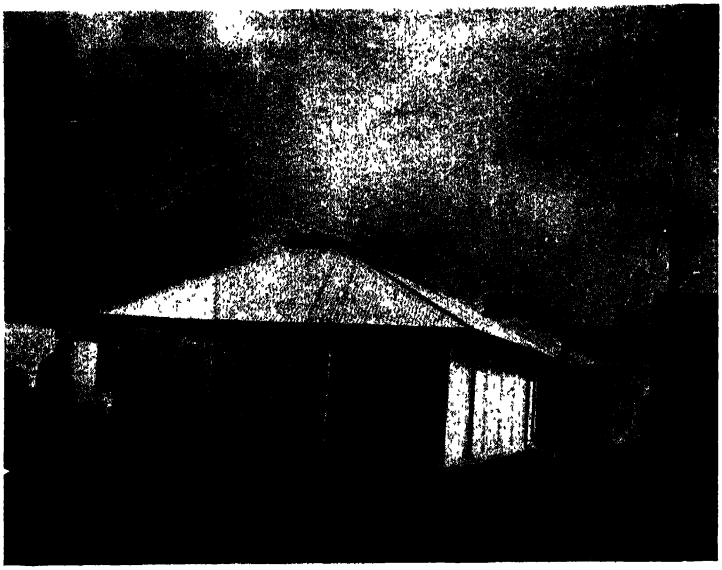
Ore Bins, Randfontein Central Gold Mine Co.

These ore bins are placed near the 600 stamp battery, and the ore is conveyed to them by a double railway track on which run 40-ton bogey trucks, having a side discharge. The capacity of the bins is about 1,500 tons, and the bridgework over them is open, consisting of reinforced concrete main beams and stiffeners, which are calculated for locomotives of 17 tons on the driving wheels.

The walls vary from 9 in. to 6 in. in thickness, and are stiffened with counterforts and horizontal beams.

The reinforcement consists of mild steel bars.

Somewhat similar



NATIVE COMPOUNDS ALONG THE REEF.

bins have also been constructed for the Nourse Mines.

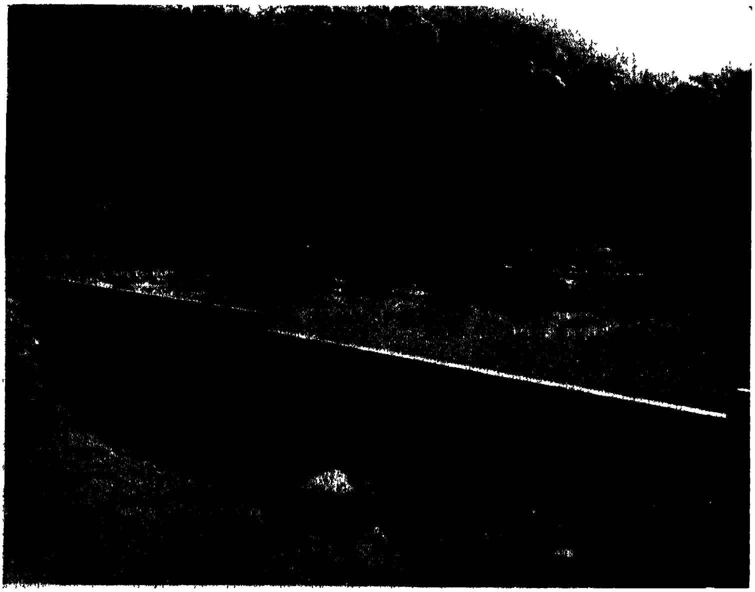
Native Compounds.

The writer has constructed a considerable number of these buildings, sufficient, in fact, to accommodate over 10,000 boys, for various mines along the Reef.

The principle adopted by him is that of casting the walls in slabs about 8 ft. in width by the height of the building, usually 10 ft., and raising them by means of a derrick.

The thickness of the slabs is 3 in., and they are reinforced with plain steel bars which project beyond their ends and are embedded in reinforced concrete buttresses.

This system admits of fairly rapid construction, the rooms, 28 ft. by 25 ft., being completed at the rate of one in three days, including foundations, roofs, and lowered ventilators.



REINFORCED CONCRETE DAM NEAR JOHANNESBURG.

Reinforced Concrete Dam.

The accompanying photographs show the upstream and downstream views of a reinforced concrete dam, designed and constructed on the farm, Rietvlei, near Johannesburg.

It is probably the first dam of this type completed in South Africa, and takes the place of no fewer than four earth dams, which have been carried away by the sudden floods, to which the supply stream, like most others in South Africa, is liable.

The upstream face has an inclination of 45°, and is supported on reinforced concrete ribs spaced 10 ft. apart. The foundations are partly on rock and partly on clay, and are formed by a grid of reinforced concrete beams.

During its construction it was exposed to severe frosts, and afterwards remained dry for five months, with a differential night and day temperature of about 100°, until filled by the first flood of the rainy season, so that it may be supposed to have undergone the most severe trial to which a dam is liable.

REINFORCED CONCRETE DAM NEAR JOHANNESBURG.

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete. These particulars have been prepared for this Journal by Mr. A. W. Farnsworth, of Strand Chambers, Derby. The last article appeared in our issue of October, 1912.—ED.

Improved Hollow Beam of Cement or Concrete and Apparatus for Making Same. — *No.* 22,196/12. *F. Emmrich and U. Silbermann. Accepted January* 9/13.— The principal points about this invention are the use of hollow supporting beams for

Fig 1

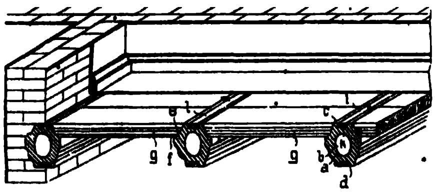
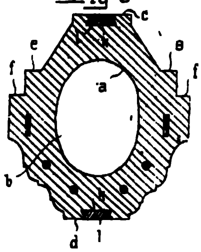
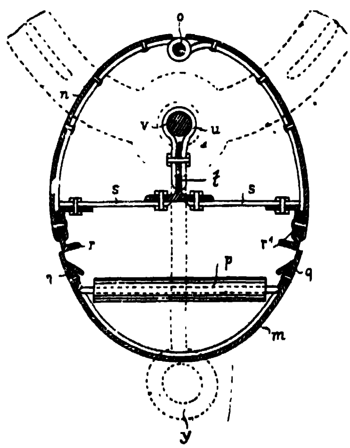


Fig 3



floors, having egg-shaped cores. *Fig.* 3 shows a section of beam adopted, *e* and *f* being ledges upon which the flooring slabs are carried, *k, k* being wood insets on top and bottom for easy attachment of floor and ceiling materials. The hollow interior being egg-shaped it is claimed gives a much lighter beam than ordinary, since the construction allows of the walls being made thinner than is usually the case. *Fig.* 1 shows, in perspective, one type of floor for which these beams may be utilised. *Fig.* 4 shows the metal core which is used for producing the hollow beams when moulding. It is made in upper and lower sections out of metal materials. The lower section (*m*) carries a series of small rollers (*p*), and the upper section is hinged at *o; t* is a girder running longitudinally through the core carrying strips (*s*) pivotly connected so that when, by means of screws, the girder (*t*) is moved lengthwise in the core, the sides (*n*) of the casing are caused to come inwards, hinging around *o*. The upper portion of the mould thus falls down on to the rollers (*p*), being guided by the L's (*r*) falling down the sloping sides (*q*). When in this manner the top half of the mould has fallen on to the rollers it is easily pulled away and the bottom half (*m*) of the mould is then slightly lifted and withdrawn.

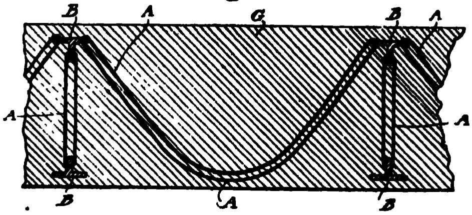
Fig. 4



Improved Arrangement of Constructional Steel or Ironwork or Reinforcement for Concrete and the Like.—*No.* 5,154/12. *J. D. Roots, M.I.M.E. Accepted January* 23/13.—With the object of providing a simpler and cheaper construction of metallic reinforcement for concrete, involving less time and labour in fitting same into position than other forms of reinforcement and yet be equal to most known methods in strength, the inventor uses tapes or ribbons or bars of flat steel for connecting the main reinforcing members together. In *Fig.* 1 is shown a floor constructed on this method. *B, B* are T-bars, into the webs and tables of which have been placed slots staggered relatively to one another and at suitable distances or intervals in accordance with the load or

stress on the floor. Into these slots are laced the steel ribbons, as shown in *Fig.* 3, so that a continuous lacing effect is obtained as between the top and bottom main members. Various modifications are also shown and alternative methods of construction, including the design as applied in the case of columns, pillars, etc. The inventor does not confine himself to main members composed of T-section only, but illustrates several other sections.

Fig. 1.



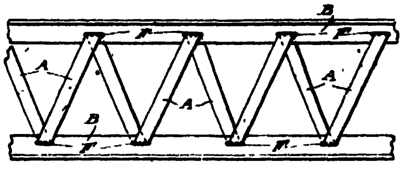


Fig. 3.

Improvements in Reinforced Concrete Beams.—*No.* 15,889/12. *J. T. McNay: Accepted January* 9/13.—The inventor describes here a method of holding reinforcing bars more or less rigidly within the mould, so that when ramming of the concrete

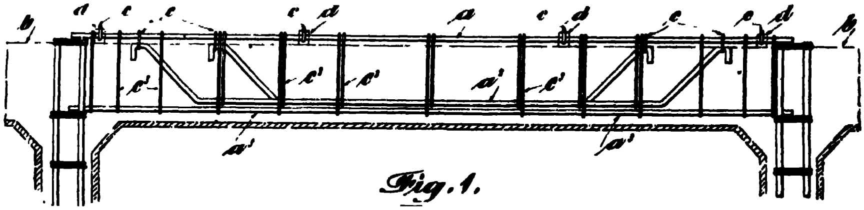


Fig. 1.

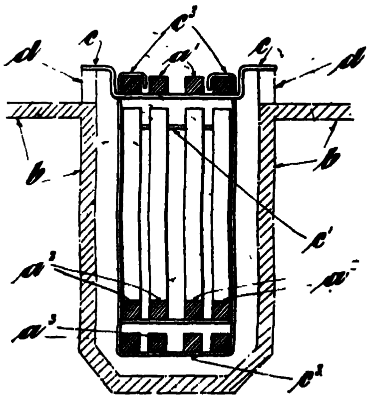


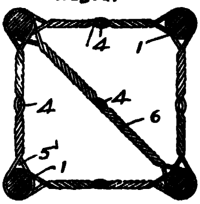
Fig. 2.

material takes place these bars shall not be displaced or upset in their various relationships with each other. He explains that in the ordinary way, when reinforcing bars are not rigidly held in the mould, a great deal of time is wasted in setting and there is always the risk of the bars getting knocked out of position or being improperly placed in the concrete. The method is illustrated in *Fig.* 1 in the case of a longitudinal beam supported by columns. The ordinary centering is placed in position, as shown at *b* in *Fig.* 2; blocks (*d*) are placed on the top edges, and on these rest dropped bars (*c*) which carry the top reinforcement members (a^1). From these latter members looped bars (c^3) are suspended for carrying the upper ends of the bottom reinforcing members (a^2 and a^3), their lengths being proportionate to the proper distances required for setting them in the mould. *Fig.* 1 shows these looped bars in position. The mould is then rammed with concrete, the centering afterwards knocked away and projections dressed in the ordinary manner.

Improvements in Reinforced Concrete.—*No.* 11,962/12. *D. G. Somerville. Accepted January* 23/13.—This deals with the twisted wire method of securing main reinforcing members together. It is stated that by the use of this method it is not

necessary for main members to be slotted or specially shaped, since the wrapping of the wire round them causes the latter to grip them firmly when finally twisted together. An added advantage is stated to be that subsidiary members can be added before the reinforcement is *in situ,* since the whole of the latter can be built up in the workshop or in any other convenient place and then dropped into the mould as a whole. Thus such members cannot be displaced during the ramming of the concrete in the moulds, but they, and also the main reinforcement members, will be kept in their proper assigned place. *Fig.* 4 shows a diagram of the annealed mild steel wire used wrapped round four main steel members, the arrangement being such as to leave at least two parallel lengths of wire one on either side of the main members. These are then engaged by a tourniquet, or its equivalent, and twisted round one another until the desired tension and an effect like that illustrated in *Fig.* 1 are obtained. During this procedure the main members must be held immovable in a suitable framework. It is stated that after the withdrawal of the tourniquet the central eye, 4, may in some instances be pinned to the concrete, although generally the twisted wire will be securely anchored without this extra assistance.

Fig. 1.



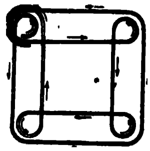


Fig. 4

Improvements in and relating to Consolidating Concrete within Moulds. — *No.* 3,248/12. *H. C. Heide. Accepted February* 6/13.—The underlying idea of this invention is to obtain homogeneity in concrete constructions made in moulds. In order to consolidate the concrete, the table or supporting platform upon which the moulds are placed for filling is pivotly mounted and is combined with means for imparting suddenly-arrested vertical rocking movements in intersecting vertical planes. *Fig.* 1 shows the table (*g*) supported upon a suitable framework and pivotly mounted on *f*. *Fig.* 2 shows a plan of the framework, and gearing is introduced so that tilting movements are imparted in such manner that each corner of the platform receives two or more blows in quick succession. Various cams are used, so that the order of the blows or shakes may be varied as desired. *Figs.* 3 and 4 show this. The specification describes the construction in detail.

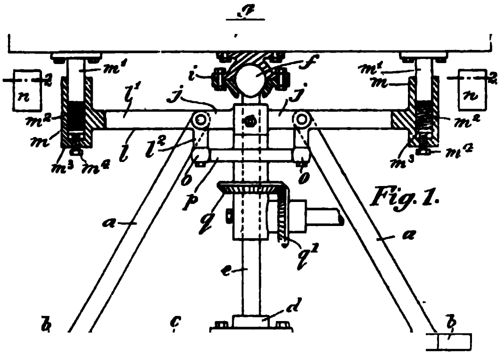


Fig. 1.

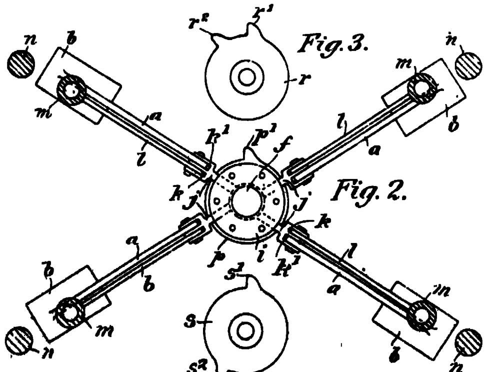
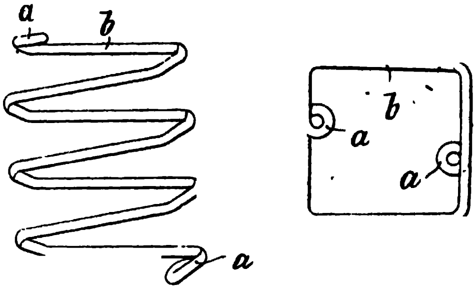
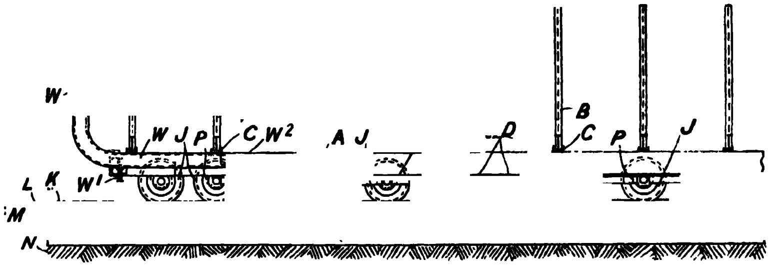


Fig. 2. *Fig. 3.* *Fig. 4.*

Improvements in and relating to the Reinforcement of Concrete Structures. —*No.* 5,872/12. *J. S. E. De Vesian. Accepted February* 6/13.—The object of this invention is to provide improved means of looping or binding longitudinally reinforcing members wrapped with short lengths of spirally-wound metal. The helical

windings are each provided with a complete loop at each end with or without additional loops adapted to encircle other longitudinal rods. In the sketches *a*, *a* are loops formed at the ends of the windings *b*, *b*, and the latter may be right- or left-handed helicals, or they may be right- and left-handed helicals alternately disposed with or without a short interval between the windings. Preferably the windings will be formed on a mandrel or template before use, and they would then be threaded on to the vertical bars as soon as the bars are put into position. It is stated that, employing short helicals instead of long lengths, the members can be disposed and arranged with much greater facilities than when long lengths of wire are used.





Improvements in or connected with Means Employed in the Construction of Barges or other Vessels of Reinforced Concrete and in Vessels Constructed of such material. —*No.* 2,138/12. *N. K. Fougner. Accepted January* 27/13.—Not very much progress has yet been made in the art of constructing reinforced concrete barges or vessels, and this is a device designed to facilitate the building of composite hulls without the great expense which has hitherto attended experiments made in this direction. The principal feature of the invention is a special cradle, upon which the forms for receiving the concrete can be readily and cheaply laid. *Fig.* 1 shows this in part sectional elevation, and *Fig.* 3 in half-cross section with moulds in position. It will be seen that the central idea is to provide a strong steel under-body furnished with a sufficient number of wheels which rest upon a railed platform. The rails are arranged sloping towards the water, and the cradle is held in position by a windlass and rope. When the barge is ready for launching, the windlass is operated and the cradle rolls on its rollers into the water, where the hull floats off its supports. The cradle is then hauled back again and re-building commences.

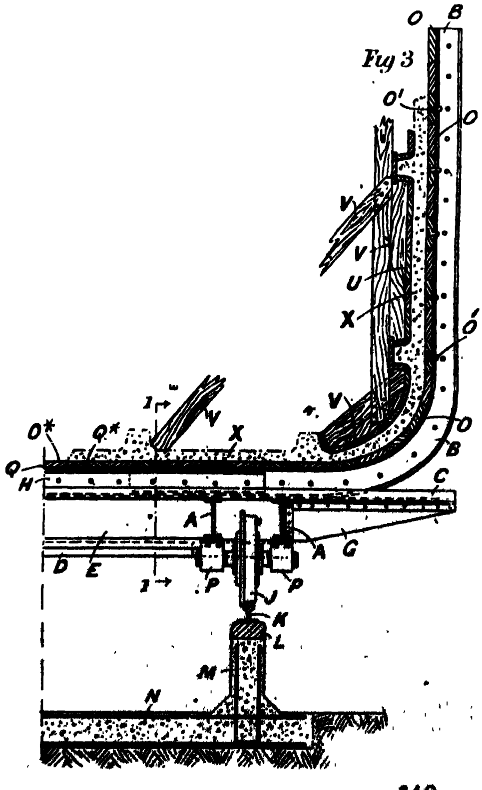
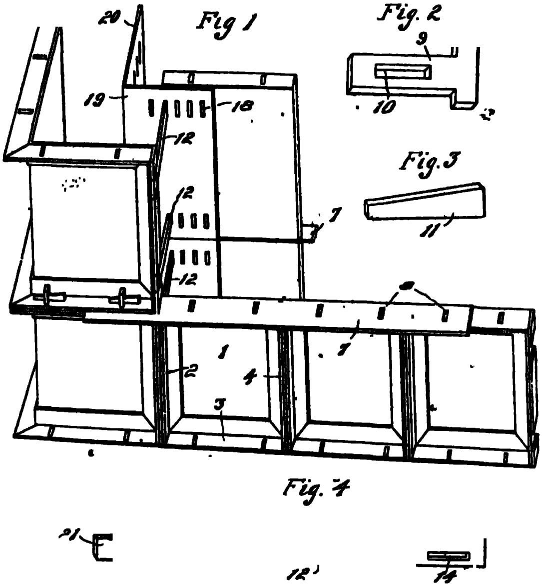


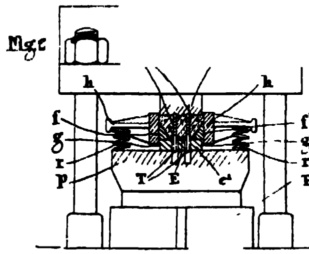
Fig 3

The construction is shown in detail in the various drawings, and the operation of building the hull upon the cradle is further described.

Improvements in and relating to Moulds for Casting Concrete and Like Walls. — *No.* 11,072/12. *W. M. Venables. Accepted January* 30/13.—This is an attempt to improve the assembling of wall moulds of the kind constituted by rows of abutting flanged plates. *Fig.* 1 shows these moulds in perspective elevation, and it will be seen that square flanged plates are employed, these being joined together by means of slots (8), through which pins and wedges, as shown in *Figs.* 2 and 3 are inserted. The walls are kept the right distance apart by means of distance pieces, shown in *Fig.* 4, likewise held in position by wedge constructions. In order to obtain perfect alignment, flat strips (7) are inserted between the flanges of the plates, either vertically or horizontally as may be required, and it is claimed that when this construction is made of light steelwork it is very readily erected, that it gives a good surface, that the plates are kept properly in alignment, and that a good job is made.



Improved Process for the Manufacture of Sleepers of Reinforced Concrete—*No.* 13,565. *G. H. Gin. Accepted January* 16/13.—This invention describes a process for the manufacture of sleepers of reinforced concrete, according to which the sleepers are composed by casting of wet or sloppy cement mortar poured in a special mould into which has previously been placed the reinforcements with or without metal fibre, and the spiral strips for reinforcing the screw-threads mounted on standard pattern coach screws. *Fig.* 2 shows the hydraulic press in which the sleepers are produced, together with the mould for same in position. *Fig.* 3 shows the spiral strips used for reinforcing the screw-threads of the coach screws which are cast in position. The inventor describes the process of moulding at length, which is, briefly, that the mould is so composed that the top and bottom can slide vertically up and down within the side members, so that when pressure is being applied and the water begins to flow away from the sloppy cement mortar, the sleeper may be brought to the proper size as the bulk of the mortar gets less. After pressing, it is stated that the sleepers are practically dry, and may be immediately removed from the mould and the process continued.



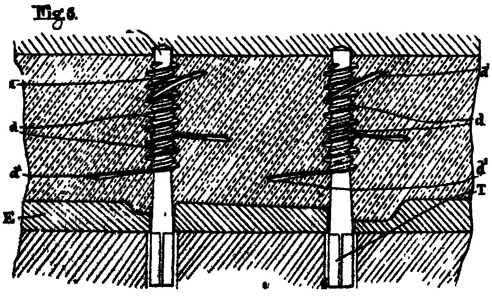


Fig 1

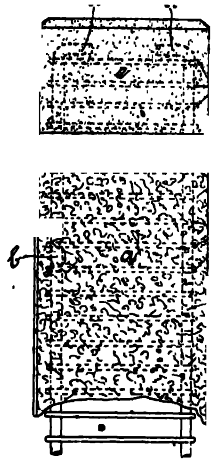
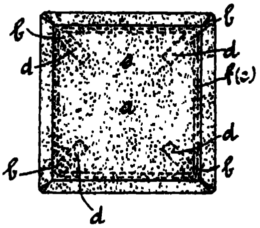
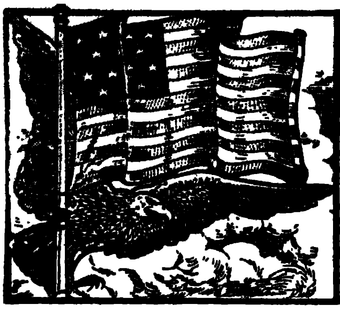


Fig.2.



Head for Reinforced Concrete Piles.—*No.* 17,682/12. *F. J. Stulemeyer. Accepted January* 9/13.—The well-known difficulty in driving concrete piles without hurting their heads is here dealt with by providing such piles with heads which are made of flexible material, similar to mortar and firmly connected with the body of the piles. *Figs.* 1 and 2 show that this is attained by making the reinforcing bars (*b*) of the pile body longer than usual, so that they project. The line *A, B* in *Fig.* 1 represents the end of the pile proper, the portion above the line being the capping material. Horizontal binders (*f*) may be employed in the cap similar to those in the body of the pile. In order that the head may be easily removed after driving, a separate layer, made of paper or similar material, is introduced on the surface *A B*. The head is then composed of a mixture either of cement and asbestos fibres or cement and saw-dust, or cement, saw-dust and magnesite or some other flexible mortar in which fibrous material such as hemp, cellulose, and the like may be employed. It is claimed that this construction saves considerable expense and has many advantages.



CEMENT AND CONCRETE at the NATIONAL ASSOCIATION OF CEMENT USERS, U.S.A.

TESTS OF WATERPROOFING FOR CONCRETE.

By CLOYD M. CHAPMAN,
Engineer in Charge, Westinghouse, Church, Kerr & Company, New York, N.Y.

The following Paper was read at the Ninth Convention of the National Association of Cement Users, U.S.A.—ED.

So much that is contradictory has been said and written concerning various methods of producing concrete which is waterproofing, and so much has been claimed by the vendors of various compounds which have been offered to the public as a positive solution of all waterproofing problems, that it is not surprising that not one cement user in ten has any definite or fixed opinion as to how to meet the problem of producing a waterproof concrete. There seem to bo as many opinions on the subject as there are men willing to express their opinions. And the many methods which have been used differ greatly from eacn other. They are not all bad, for some of them have been very successfully applied. They are not all good, for many failures have occurred.

To throw more light upon the effectiveness of the various methods of waterproofing concrete a great many tests have been made by numerous investigators. The methods used by these experimenters have ranged from absorption tests to high-pressure tests necessitating more or less elaborate apparatus.

The absorption, or non-pressure, tests are made by preparing specimens of any predetermined size and shape of the concrete waterproofed by the particular methods under investigation. After the desired age is attained, these specimens are either immersed in water completely or immersed almost completely, or placed in shallow water so that the bottom only of the specimen is wet; or the specimen may be made cup-shaped, so that the water may be placed in the depression in the specimen, or a container for the water may be attached to the surface of the specimen.

In all these forms of tests the results are expressed in terms of the amount of water absorbed or the rate of absorption.

In the pressure tests the specimen is either so made that the water-pressure may be applied to the interior of the test piece, or it is so made that it may be inserted in the apparatus in such a manner that the water-pressure may be applied to a certain area on one face of the test piece. In this form of test the results are expressed in terms of the amount of water passing through the specimen or the rate of flow through it.

Both the above tests are very valuable if carried out in such a manner that the results may reasonably be expected to compare with results which may be obtained in practical work. To this end it is desirable that certain precautions be observed in preparing specimens and conducting tests, so that the results shall not be misleading or deceiving.

It is the purpose of this paper to call attention to some of the features of tests of this class and to emphasise more strongly certain precautions, failure to observe which may cause some of these tests to give very deceptive data. These precautions apply particularly to tests made for the purpose of determining what method shall be used on a particular piece of work in the field. Some of them do not apply to tests designed only to compare the relative efficiency of various methods, without regard to any particular work at hand.

First: The selection of the materials to be used in making up the test pieces. These should be selected from those available at the site of the work which is to be done. This is particularly true of the fine and coarse aggregates. It has more than once happened that tests made with suitable aggregates have shown a particular method to give a waterproof concrete, but the same treatment failed when the aggregates available in the field were used. If, therefore, it is desired to determine by test how to produce a waterproof concrete for a particular job, the materials available at the job should be used in making up the test pieces. It is also important, in connection with the selection of aggregates, that there be secured a sufficient quantity of the materials to be used to conduct the entire line of tests contemplated, so that there need be no change in the materials used.

Second: The proportioning of the materials: This should be done with a view to determining the proportions to be used later on the work. The proportions to be used in the tests: There is little use in testing only a 1 : 2 : 4 concrete for watertightness, and then use 1 : 2½ : 5 on the job.

Third: The mixing of the materials. This should duplicate as nearly as possible the mixing to be used on the work. Many a well-mixed concrete has proven waterproof which would have failed utterly if carelessly mixed. There is a tendency to very thoroughly mix concrete for a test, and then make no special provision for thorough mixing on the job.

Fourth: The consistency of the mixture. This should be carefully considered because of its influence upon the results. A consistency should be chosen which it is practical to use on the job under the circumstances prevailing there. For instance, it is useless to test a concrete of so thick a consistency that it would have to be spaded into the forms if, on the job, the concrete is to be spouted from the elevator, and, therefore, necessarily of a much thinner consistency than was used in the test.

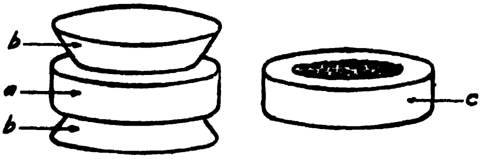
Fifth: The moulding of the test specimen. This process should imitate as nearly as possible the filling of the forms as it will be done on the job. To make a test piece by putting into the mould a small quantity of concrete at a time, and constantly tamping during the filling process, would probably produce a deceiving result.

Sixth: The finishing of the surface to be tested. This is one of the most important points in the preparation of test specimens. The condition in which that surface which is to be subjected to water is left has a very great influence upon the results obtained. For instance, it is quite possible, by means of a little trowelling, to produce a skin, or surface coating, of nearly neat cement. This will produce a dense surface much more impermeable than the body of the concrete, and show results far superior to an untrowelled specimen of the same concrete. It is recommended that specimens be so prepared that the surface exposed to test truly represent the body of the concrete. This may be accomplished by removing the surface of the specimen after the concrete has hardened by means of a wire brush or by chipping or breaking off the surface before test.

In the case of absorption tests this may be done with a stiff wire brush when the specimen is about twenty-four hours old. In the case of the pressure tests, only that portion of the surface which is to be subjected to the pressure and that portion from

which the water passes out of the specimen need to be removed. This may be accomplished by making the test piece with additional material added to the surfaces to be tested, so that this additional concrete may be broken off after the specimen has hardened and before the test is performed. Unless some such precaution is taken, tests of this character are liable to show the efficiency of the surface of the specimen in resisting the water-pressure rather than the value of the mass of the concrete in performing the same function.

One suitable form for a specimen for pressure tests is shown in the accompanying illustration. It is in the form of a central disc, *a*, of suitable diameter and thickness.



The outside surface and the outer portion of the two faces of this disc are moulded smooth and regular, so as to fit the receptacle or holder into which it must be placed, in order to apply the water-pressure to a definite and restricted area of its surface. From the central portion of the two faces of this disc project truncated cones, *bb*, whose smaller diameter is just equal to the diameter of the circle which is to receive the water-pressure. After the specimen has hardened and is ready for test, the two truncated cones are broken off with a blow of a hammer, leaving a disc such as is shown at *c*.

By this method there is exposed to the water-pressure a freshly broken surface of concrete which has not been subjected to trowelling or other influences tending to alter the natural condition or distribution of the constituents of the concrete. This freshly broken surface is not only presented to the water on the side to which the pressure is applied, but is also provided on the opposite side where the water leaves the specimen. The test, therefore, is made on a certain thickness of concrete taken from the interior of the specimen, and the results are not influenced by the method of finishing these two surfaces.

There are, of course, cases in which it is the surface permeability that it is desired to test, and in such cases this form of specimen is unsuitable. But in all cases in which the watertightness of the concrete mass is to be determined the above type of specimen is much to be preferred.

There are also variations of this form of test piece which will accomplish the same result. Any method which removes the finished surface from the area to be tested is to be preferred to one which does not remove that surface.

Even in such cases as those in which the specimen is moulded on a surface of glass or other smooth material and no trowelling is done, there is a concentration of cement and fine aggregates next to the surface which must affect the results obtained if this richer layer or skin is not removed before test.

Seventh: The curing or ageing of the specimen. This matter should also be decided with a view to conditions which will prevail in the field when the real work is done. If it is impracticable on the job to keep the concrete constantly wet for a considerable period, then the test specimens should not be stored in water. If the only wetting the work in the field is to receive is the water contained in the concrete when it is placed, then the test pieces should receive no additional water after moulding. On the other hand, they should not be allowed to dry out any faster than would the work in the

field, as they would doubtless do owing to their comparatively small size if kept indoors in a laboratory and no precautions taken to regulate the drying process.

The specimens have now reached the stage when they are ready for whatever tests are to be applied to them, and the methods used in performing these tests are so varied that the limited scope of this paper will not permit an extended discussion of them. Those with which the writer is familiar appear to be open to little, if any, criticism. One of the most important features is that the conditions adopted shall remain constant throughout the test.

If the test is an absorption or a non-pressure test the immersion or partial immersion should be under uniform conditions and for definite lengths of time in clean water. If the test is a pressure test, the pressure should be kept constant, the water clean, and the method of measuring the water passing through the concrete accurate. As the area subjected to pressure is usually small, the amount of water passing is correspondingly small, and in some cases where the measurement of the water is made by collecting the drippings from the underside of the test piece the element of evaporation may greatly affect the results. A form of apparatus in which the amount of water passing into the specimen is determined eliminates this error.

In this form of apparatus the specimen is clamped and sealed to a metal cap which is provided with a projecting vertical graduated glass tube. The cap and the tube are filled with water and air-pressure is then applied to the top of the tube in any desired amount. As soon as the specimen has become saturated and water begins to flow from its exposed face a reading is taken of the water in a graduated glass tube, and thereafter readings are taken at regular intervals of time during the period of the test. If it is necessary to introduce more water into the system when testing porous concretes, this may be done by opening an inlet which is supplied with water at a higher pressure than that of the air in the tube and so filling the glass tube again up to the zero mark.

By this method accurate determinations may be made of the amount of water forced into a concrete which is so near waterproof that all, or a great part, of the water which passes through it would be evaporated from the exposed surface.

Another matter in connection with tests of waterproofings for concrete which seems to have had but little attention paid to it is the effect of time and the elements upon efficiency of the waterproofing materials. In practically all of the numerous tests of waterproofing made in the past seven or eight years in the laboratory of Westinghouse, Church, Kerr & Company, it has been the custom to expose the test pieces to the action of the weather on the roof of their office building after first testing them, and then testing again after six or twelve months' exposure. The results of these tests after prolonged exposure show that few, if any, of the materials which are applied to the surface of concrete to waterproof it after it is made will retain even a fair proportion of their efficiency. In the case of those methods by means of which the entire mass of the concrete is designed to be waterproof, there is shown sometimes a steady improvement after exposure and sometimes a marked decline. In some cases the life of the treatment is very short and the failure after a few months' exposure almost complete.

It is important, therefore, before any particular method of waterproofing be adopted, that the probable life of the treatment be ascertained. It is pretty well established that a good concrete without foreign substances in it improves with age, becomes more dense and watertight, but the same cannot be said as positively of a concrete containing some of the recently developed compounds intended for waterproofing.

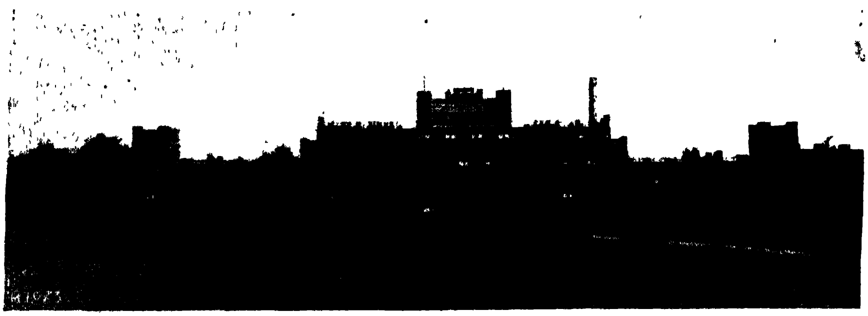


Fig. 1. General View.

THE WORK OF THE GROSS-LICHTERFELDE TESTING STATION.

The following article on the Gross-Lichterfelde Testing Station, Berlin, should be of interest to those of our readers who follow the research work carried on in different countries, as this testing station undoubtedly takes a very high rank among our scientific institutions. This article has been prepared for us by Dr. Cecil H. Desch, of the Glasgow University, and Professor Martens, Director of the Testing Station, kindly placed the illustrations at our disposal.—ED.

Generally.—The report of the Royal Station for the Testing of Materials at Gross-Lichterfelde, near Berlin, has now been published for the year ending March 31st, 1912, and affords a convenient opportunity for considering the nature and extent of the work carried on in this celebrated institution. The six departments of which the Station consists have come into being at different times between 1871 and 1886 to meet the needs of the Charlottenburg Technical School, the Berlin Academy of Mines, and of various public departments and associations of manufacturers. The accommodation provided at Charlottenburg from 1884 onwards proving insufficient, a new Institute was erected at Gross-Lichterfelde, and was opened in 1904.

Our illustrations, *Figs.* 1 and 2, show the vast size of the building, which is situated between the main road and the railway, on the way from Berlin to Potsdam. The site secured is of ample dimensions, to allow of future growth, and also to provide sufficient space for open-air tests and for temporary erections. The equipment is admirably complete, and the handsome "Denkschrift" published on the occasion of the opening, and giving full details of buildings, plant, and apparatus, should serve as a standard work of reference on the important subject of the equipment of laboratories for the testing of materials.

The staff of the Testing Station was composed in 1911 of 227 persons, no less than 74 of whom had received a University training. The director is Prof. A. Martens, whilst the sub-directors and chief assistants include such well-known names as those of Professors Rudeloff, Gary, Heyn, and Burchartz, the connection with the teaching staff of the Charlottenburg Technical School having been maintained since the transfer to the new site.

EXPLANATION OF LETTERS ON BLOCK.

A—Principal Building.
B^V—West Testing Rooms.
B^L—West Laboratory Building.
M^V—East Testing Rooms.
M^L—East Laboratory Bui'ding.
W—Workshop.
C—Engine House.
D—Accumulator Bui'ding.
SR—Cooling Tower.
F—Fire Laboratory.
K—Boiler House

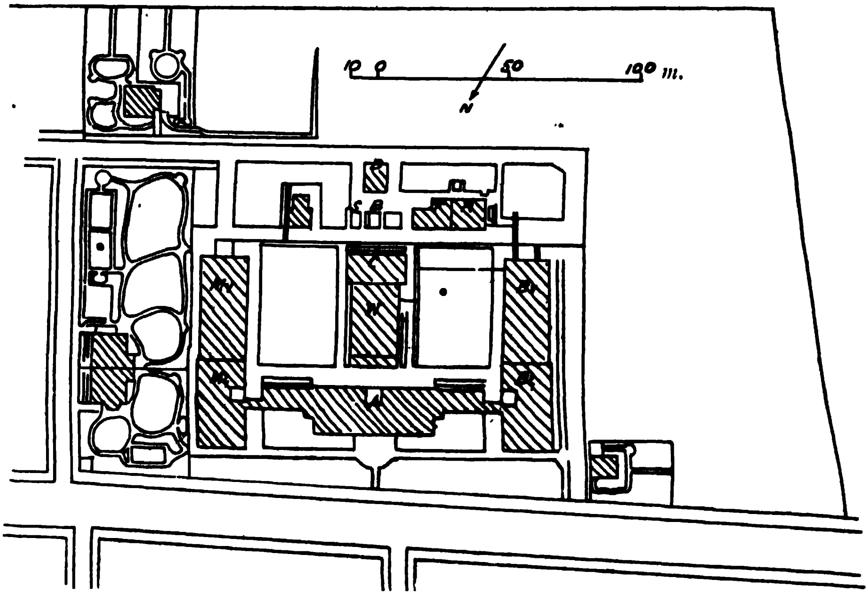


Fig 2. Plan.
GROSS-LICHTERFELDE TESTING STATION, BERLIN.

The following are stated by the director to be the principal objects of the Testing Station :—

(*a*) The improvement of methods, machines, instruments and apparatus employed in testing, in the public interest.

(*b*) The testing of materials and structural members :—

1. In the interests of the public or of science, so far as the means are provided by the State or by private persons.

2. At the request of public bodies or private persons, against the payment of a fee, official certificates being granted.

(*c*) At the request of both parties to decide in cases of dispute as to the strength or quality of materials or structural members.

Further, as far as the interests of the institution permit :—

(*d*) Instruction of students in the Technical High School and the training of young assistants in the practice of testing.

(*e*) The encouragement of research in certain special departments by allowing the use of the equipment by outside investigators.

The work of the Testing Station is distributed over six departments—

namely, metals, building materials, paper, metallography, general chemistry, and oils. Of these, the second is naturally of principal interest to the readers of this journal, but the first also includes much work of importance to the constructional engineer.

Fig. 3. Large Press.
GROSS-LICHTERFELDE TESTING STATION, BERLIN.

The department for the testing of building materials occupies the ground floor of the western wing, together with special rooms in other parts of the building and huts, etc., on the surrounding ground. The photograph, *Fig.* 3, shows the principal testing room of this department, provided with four com-

pression machines, of 400, 150, 40, and 33 tons capacity respectively, as well as 5- and 2-ton presses for transverse tests. All these presses are hydraulic in action, and the loads are read by means of pressure gauges. The same room contains the machines for testing cement briquettes in tension, and Gary's

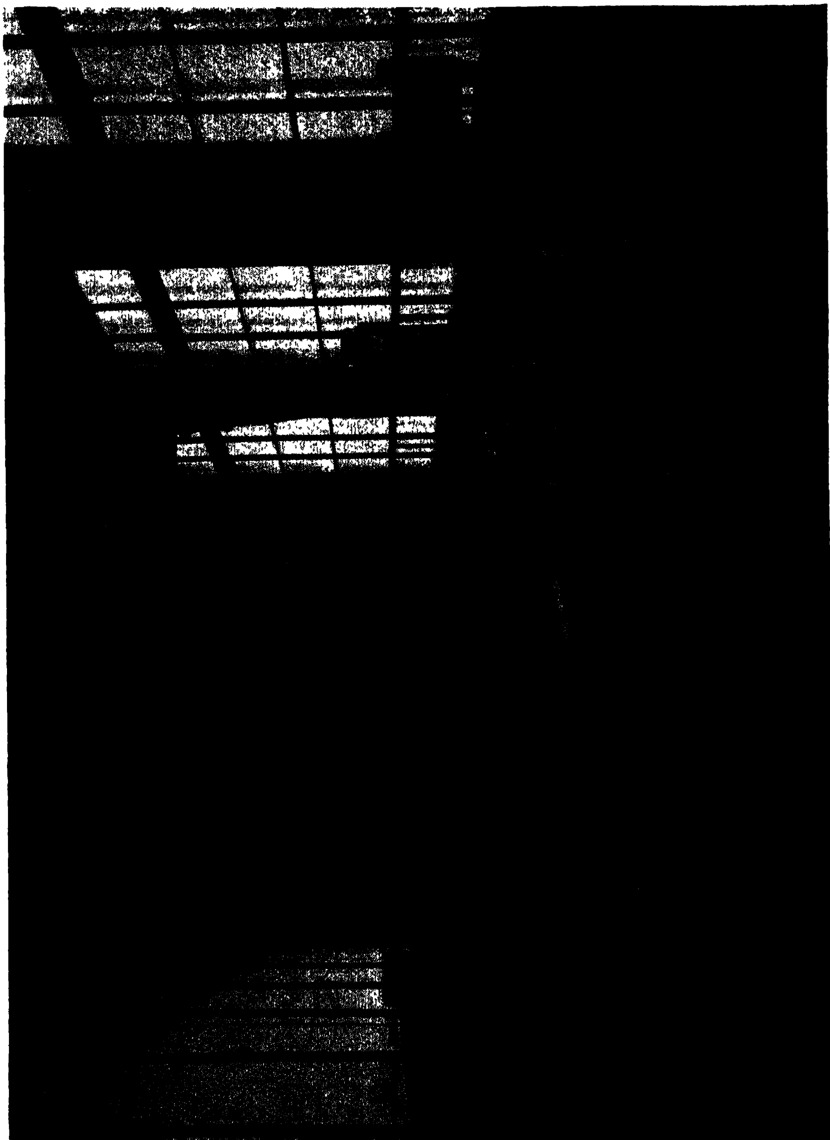


Fig. 4. Cement Testing Room.
GROSS-LICHTERFELDE TESTING STATION, BERLIN.

apparatus for determining the permeability of mortar and concrete to water. The great 500-ton horizontal testing machine shown in *Fig.* 4 belongs to another section, that of metallic materials, but it is also used for bending and crushing tests on reinforced concrete columns and similar purposes. Such objects as

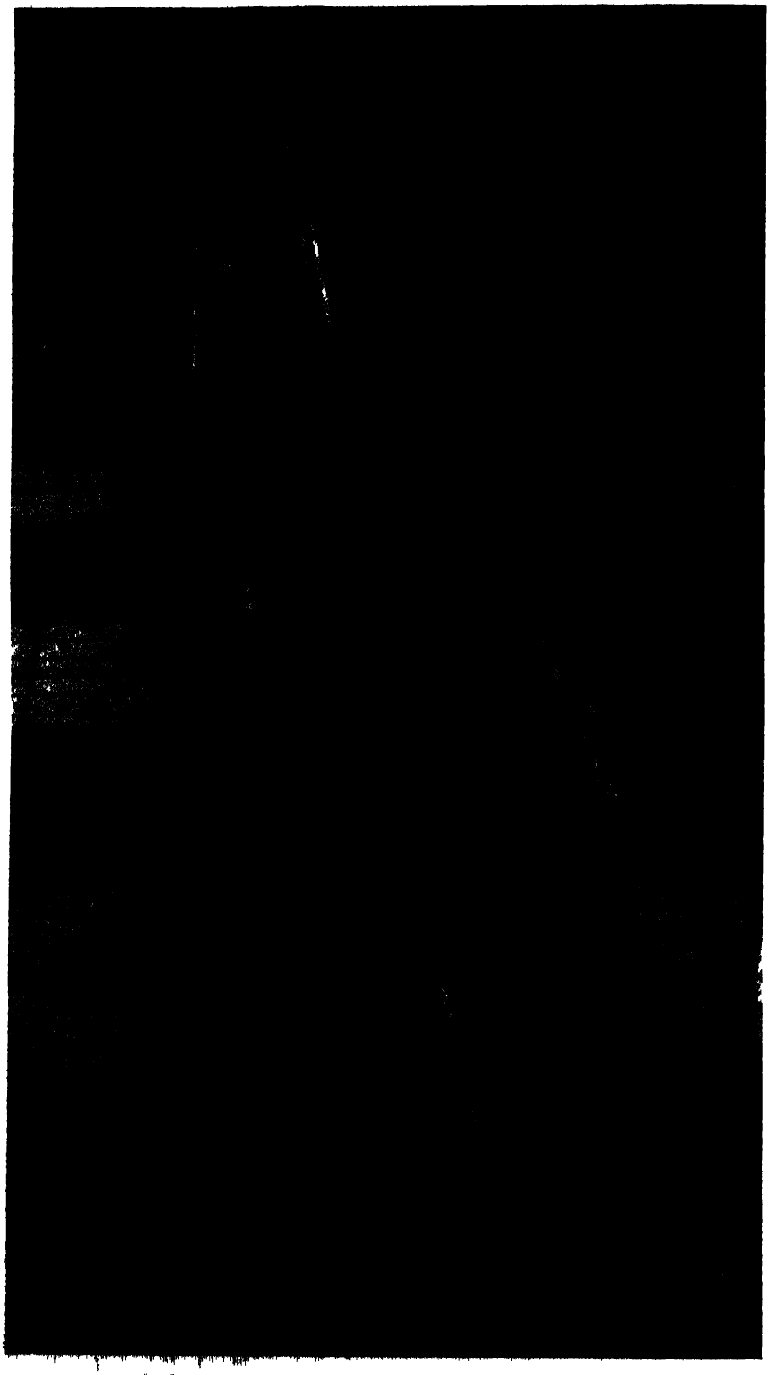


Fig. 5. 3,000-T Machine built for the German Iron and Bridge Building Institution by Hanel & Lueg, Düsseldorf
Gross Lichterfelde Testing Station, Berlin

reinforced concrete pipes are also tested by means of machines belonging properly to the metal section. Our photograph, *Fig.* 6, shows the tower in which falling weight experiments are carried out. The department is also amply provided with equipment for chemical analyses, for the making and storage of cement and concrete test-pieces, and for special tests of the resistance of materials to weather, frost, chemical fumes, etc. To another subject—the fireproof qualities of materials—further reference is made below. *Fig.* 5 shows the great 3,000-ton machine which has been recently installed. This enormous press—by far the largest in Europe—has been erected at the request of the Union of German Bridge and Structural Steel Firms by Messrs. Haniel & Lueg, of Düsseldorf. It can take entire girders, struts, columns, and built-up bridge sections, in compression or tension.

The extent of the work of the building materials section may be judged by the following facts taken from the report for 1911-12. The total number of applications was 1,023, involving 39,000 experiments, of which about one-half dealt with cements of different kinds.

Cement.—The tests with Portland cement and blast-furnace slag cement ("Iron-Portland") showed a steady improvement in quality since the raising of the German official standard. One cement showed, in a 1 : 3 normal mortar, after seven days under water, a tensile strength of 35·1 kg./cm.^{2} (499 lb./in.^{2}) and a compressive strength of 460 kg./cm.^{2} (6,541 lb./in.^{2}). The same mortar, after 28 days in water and air, gave a tensile strength of 48·7 kg./cm.^{2} (692 lb./in.^{2}) and a compressive strength of 692 kg./cm.^{2} (9,840 lb./in.^{2}), the highest value yet recorded in this laboratory.

The opinion was given, in answer to a special demand, that the spontaneous change of a slow-setting to a quick-setting cement was not to be regarded as an indication of inferior quality, as such spontaneous changes take place with changes of temperature even in good cements. Petroleum and other oils were found to weaken cement mortars very considerably when the latter were exposed to their action after 28 days hardening in air. The injurious influence is greatest in lean mixtures. Experiments were also made to test the question whether reinforced concrete could be safely employed for shafts and buildings exposed to the action of waters (potash salt liquors) containing magnesium chloride. It was found that such salts always attack cement. The addition of a "frost-protecting" substance to concrete during mixing has been recommended, and tests with such a concrete showed that if exposed to air for one day and then alternately frozen and thawed twenty-five times, no external change was produced, but that the resistance of reinforcing rods to slipping was seriously reduced by the addition of the protective material.

A frequent request is to determine the proportions originally used in mixing a concrete, from an examination of the hardened material. This is, except in the simplest cases, an operation of considerable difficulty. It is possible to determine the proportion of cement, if used alone, and in certain cases to decide whether an addition of either fat or hydraulic lime has been made to the cement, but it was not found possible to decide whether the breeze used in a certain breeze concrete was satisfactory or not. There is undoubtedly room for improvement in this class of testing, which is so important in disputed cases.

The concrete pipes used for the conveyance of water in a certain district showed corrosion after one year in the soil, amounting to destruction of one-

third of the pipes over a length of 300 metres. In this case it was not found possible to determine the cause of the corrosion. The soil did not contain acids or other destructive substances. The material of the pipes did not appear to have been well mixed, but a definite conclusion was not reached.

A number of scientific investigations were also proceeded with, the results of which have been published or are in course of publication.

Fire Tests.—The tests as to the fire-resisting qualities of materials during the year were not very extensive, being limited to some "fireproof" doors, a hut of slag-stone, a comparison of a brickwork wall with one of sand-lime bricks, and one of an ordinary lime floor with a plaster floor. The provision for this branch of testing is inadequate, and compares unfavourably with the arrangements of the British Fire Prevention Committee. It is stated that it is proposed to extend this branch of the activities of the institution after an examination of the methods adopted by kindred institutions in London, New York, Chicago.

Conclusion.—The services which a fully-equipped testing station of this kind are capable of rendering to industry are obvious. The publications of the Gross-Lichterfelde Station form a most valuable source of reference for all who are interested in such a department of industry as that of concrete construction, apart from the direct utilisation of the services of the station by German manufacturers, engineers, and building clients. We must not forget, also, the advances in methods of testing which we owe to Profs. Martens, Gary and their colleagues. Some of their methods have not been adopted in this country, and differences of opinion exist as to their value in comparison with methods due to other workers, but their share in developing the technique of testing is recognised and gratefully acknowledged by all who have followed the progress of structural materials in recent years.

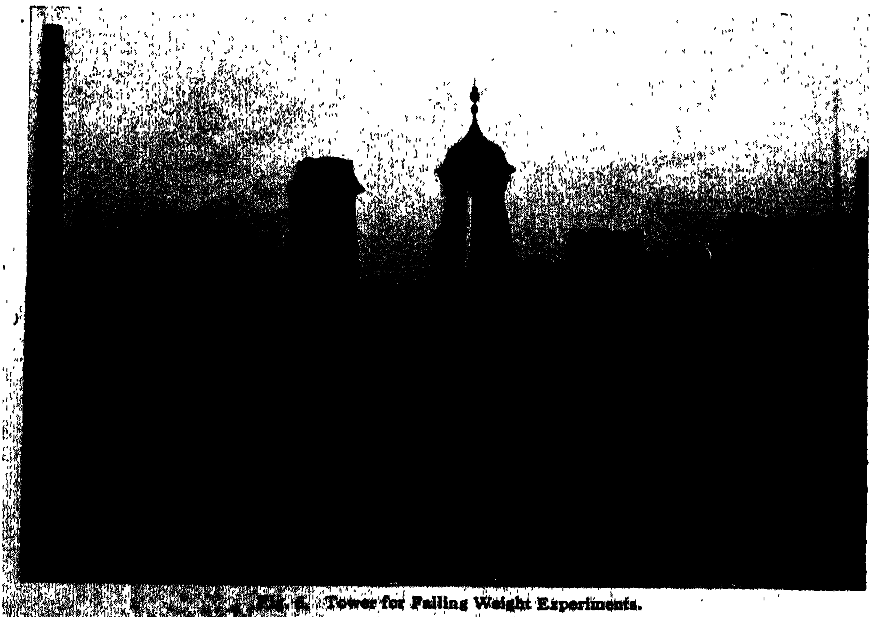
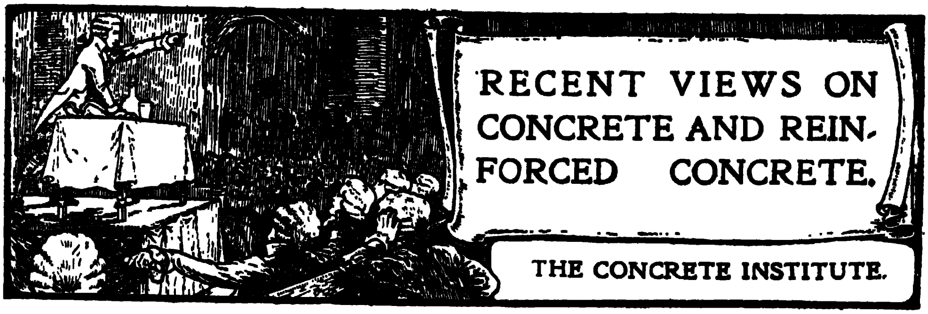


Fig. 6. Tower for Falling Weight Experiments.
Gross-Lichterfelde Testing Station, Berlin.



It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

THE SETTLEMENT OF SOLIDS IN WATER AND ITS BEARING ON CONCRETE WORK.

By DR. J. S. OWENS, Assoc.M.Inst.C.E., M.R.San.I., F.G.S.

The following is an extract from the Paper read before the Institute at their Thirty-first Ordinary General Meeting. A short résumé of the discussion is also given.

INTRODUCTION.

THE Lecturer, in opening, stated that it would only be possible to give a brief outline of the subject under review, and referred his audience to papers read by him before the Royal Geographical Society, Research Department (see *Geographical Journals,* January, 1911, and March, 1912); before the British Association in Dundee last September (see *Engineering,* December 20th last); and a paper before the Society of Engineers of March 1st, 1909.

He proposed to deal with some of the physical characteristics of stones or shingle, sand and mud, which lead to their separation into these distinct classes by nature. Practically all the sorting is done by the agency of flowing water, and the chief factor governing the position of any deposit is the ability, or otherwise, of the water to hold the material in suspension. Very finely divided matter remains long suspended, and therefore, if in a current, passes over the place where coarser matter is being deposited, and settles in less disturbed water.

With the exception to be referred to later, a heavy solid can only be supported in suspension in water by an upward thrust equal in intensity to that which would result from a current of water of the same velocity as the body would settle at in still water. This means: (*a*) it is to the resultant upward thrust due to eddies and disturbances that suspension in water is due; and: (*b*) a measure of the rate of fall of a body through water will be useful as measuring its resistance to suspension.

A solid body which is of higher specific gravity than water will sink in the latter at a definite rate. Starting from rest, it will have two distinct stages in its fall:—

1. An accelerating stage during which the force operating on the body to pull it down is greater than the retarding force due to friction and the impact of the water particles on the under surface of the body.
2. A stage of uniform motion which is attained when there is an equilibrium between the downward and upward acting forces.

In practical work the first or accelerating stage is so very short as to be negligible, except for very large bodies.

The chief factors governing the rate at which a body will settle through water are: (1) its size, (2) shape, (3) specific gravity, (4) the temperature of the water, or any cause affecting the viscosity of the liquid, (5) the quantity of suspended matter present in the water.

SIZE.

If v represents velocity of fall in foot seconds, d diameter of body in feet, s specific gravity of body, and k a constant depending on the shape of the body (equal to about 9·35 for spheres, 6·12 for irregular grains of sand, according to the author's latest experiments), the velocity of fall in water for bodies over $\frac{1}{10}$ of an inch in diameter will be given with fair accuracy by the expression :—

$$v = k\sqrt{d(s-1)}.$$

It will thus be seen that the rate of fall varies directly as the square root of the diameter.

SHAPE OF BODY.

The author found that a curious law governs the position a body of irregular shape takes up in falling through water. It is the custom to apply the law of "least resistance" to explain many phenomena in nature. If applied in the present case, it would seem to indicate that a body such as a disc will settle through water edgewise, a rod endwise, and so on; but the contrary is the case: a disc always settles on the flat, a rod with its greatest length horizontal. For this reason a sphere settles more rapidly than any other shape, and flat, thin bodies, such as slates, settle very slowly indeed.

SPECIFIC GRAVITY.

Referring to the formula given above, it will be seen that the velocity of settlement varies directly as the square root of the specific gravity of the body minus that of the liquid in which it settles. In the case of two balls the rates of fall of which were measured by the author, one was a composition ball having a specific gravity of 1·19, a diameter of ·415 in., and a rate settlement of ·794 f.s.; the other a steel ball, specific gravity of 7·77, diameter ·498 in, and a rate of fall of 4·96 f.s. If these two be compared, the velocities of fall should vary nearly as $\sqrt{s-1}$, the diameters being approximately equal, that is $\frac{0{\cdot}794}{4{\cdot}96}$ should be equal to $\frac{\sqrt{0{\cdot}19}}{\sqrt{6{\cdot}77}}$ and it will be found that this is practically the case.

WATER TEMPERATURE.

This has a profound effect on the rate of fall of fine matter in water, due, no doubt, to its influence on viscosity. A rise in temperature of the water produces an increased rapidity of settlement which is most marked with the more finely divided materials. The rate of settlement of silicious sand of $\frac{8}{1000}$ in diameter is doubled if the temperature be raised 80° F.

AMOUNT OF SUSPENDED MATTER PRESENT.

It can be shown experimentally that the greater the load of suspended matter, the slower its rate of settlement. Finely divided solid matter held in suspension in water has practically the same effect on the specific gravity of the mixture, measured by a floating hydrometer, as if it were in solution. In order to bring out this point, he had made the following experiment: Weighed quantities of whiting were mixed with similar volumes of water, and the specific gravity taken with a hydrometer. It was also calculated, assuming that the whiting had gone into solution instead of being suspended, and the figures obtained in each case compared. The results showed that the effect on the specific gravity of the mixture was the same whether the added matter went into solution or suspension.

It is reasonable under the circumstances to suspect that the amount of heavy matter suspended in a liquid will influence its rate of settlement in the same way as an alteration in the specific gravity of the liquid itself; and this is found to be the case.

PRACTICAL APPLICATION OF RESULTS.

It may first be considered how to define the meaning of the words "stone" or "shingle," "sand," and "mud." It is obvious that any definition to be of use must be based directly or indirectly upon size of grain.

There appear to be two distinct sizes of particle to which further attention must be given. It will be observed that the application of the formula given above is stated to be limited to sizes over $\frac{1}{10}$ in. diameter. The reason for this is as follows: In experimenting on the rate of settlement of different grades of material, it was found that the value of k in the formula referred to was fairly constant over $\frac{1}{10}$ in. diameter; but for grains of smaller size it fell off rapidly in value, thus showing that some factor was operating in the smaller grades which was not taken into account in the expression given. That this factor was the viscosity of the liquid he had no doubt, and its preponderating effect in the smaller grades may be due to the rapid increase in the ratio of surface to volume or weight, as the size is reduced, or to the passing of a critical point in the velocity such as that shown by Osborn Reynolds to divide streamline flow from eddying-flow.

While it is not strictly correct to speak of a critical diameter at which this effect commences to appear, it was found on plotting values of the constant k referred to that at about $\frac{1}{10}$ in. diameter the curve bent rapidly downwards, whereas above this it was practically horizontal.

There is possibly a second critical size of particle which is of interest if not of great practical importance.

The chief retarding forces operating to prevent settlement of a body in water may be regarded as :—

1. The upward impact of the water due to the velocity of fall of the body.
2. Friction, the force necessary to overcome the viscosity of the liquid.

When there is no velocity of fall (1) disappears, but some of (2) probably remains. As we reduce the size of the body the downward acting force, due to its weight, becomes smaller more rapidly than the frictional resistance, since the former varies as the cube, the latter as the square of the diameter. Hence it would seem that when the diameter is reduced to a certain critical value, the force operating to pull the body down will become equal to the frictional resistance to movement, and permanent suspension in the liquid result. As, however, there is probably no such thing on the earth as absolutely quiescent water, permanent suspension will result long before this critical size is reached, owing to movements in the water due to temperature changes or other causes. The blue colour of the sea has been attributed to the presence of fine suspended matter.

Again, mud particles sometimes approach in size the limits of microscopic vision; so that we have clearly a considerable range of size to choose from in defining mud as distinct from sand. If we decided to take all below the critical diameter referred to as being mud, we have to consider how it is that particles of such a size as to be permanently suspended in water ever reach the bottom to form mud.

A sample of yellow marl examined by the author for the purpose of this paper contained particles down to about $\frac{1}{5000}$ of an in. in diameter, and the finest of these settled through water, although at a very slow rate; for example, a glass vessel containing a column of about 12 in. of water in which a little of this clay was shaken up had not cleared after forty-eight hours in a temperature of 50° F., and after sixteen hours the water was still quite cloudy with grains about $\frac{1}{5000}$ in. diameter. It is obvious, therefore, that the critical diameter for this was under $\frac{1}{5000}$ of an inch.

CONCRETE WORK UNDER WATER.

When concrete is allowed to settle through water, the effect is to bring about an analysis into coarse and fine strata. The larger particles—stones, gravel, etc.—settle more rapidly than the finer sand and cement; with the result that they reach the bottom first and form a layer over which the sand and cement settle, also in separate strata—the cement on top, the sand underneath it. The separation is not quite complete, because the large particles always carry down in their wake some of the smaller, and for other reasons which it is not necessary to refer to here. Even when allowed to fall through only a foot or so of water, the fine cement is washed out and, to a great extent, remains suspended, owing to the disturbance of the water.

EXCESS OF WATER IN CONCRETE.

When fine and coarse particles are suspended in a liquid the coarse, by virtue of their greater weight compared with their surface, tend to work towards the bottom,

displacing the fine matter upwards; for it must be remembered that a body falling through a liquid always generates an upward current to fill the space which it occupied, and this is sufficient to keep very fine particles suspended. The case of immediate interest is that of concrete mixed with too much water; when kept in a state of disturbance by ramming there is a tendency for the coarse part of the aggregate to work towards the bottom, the finer sand and cement towards the top giving a deceptive appearance to the concrete of having been thoroughly consolidated.

CONCRETE MIXING

It is not uncommon to meet with a so-called concrete mixer which, when closely watched, is found in some cases to separate the fine from the coarse parts of the aggregate. It is easy to see from the earlier remarks made that with sufficiently liquid concrete a badly designed mixer may produce sufficient agitation to suspend the sand and cement, but not the coarser part of the aggregate, which consequently gradually separates out as a bottom layer. Of the two chief types of mixer now in use, one depends on revolving arms operating in a fixed vessel, and this is the type most likely to be affected by the cause described, unless very carefully designed with proper provision for a positive mingling of the different parts of the concrete as distinct from mere agitation. The other type, in which mixing is effected in a revolving vessel fitted with shelves, is more likely to produce good concrete, as its action depends on repeated shifting of parts of the mass from one place to another—for example, from bottom to top and sides to middle.

TEST OF CONCRETE MIXING.

The author was strongly of opinion that sufficient attention has not been given to the proper mixing of concrete. It is a process which has a perfectly definite point of completion, which is, however, not always attained to. *Concrete may be said to be thoroughly mixed when all the ingredients are as uniformly distributed as possible throughout the mass.* If this is accepted as a definition of proper mixing, then samples taken from different parts of a heap of concrete should contain the same proportion of stone, sand, and cement. The different rates of settlement of these three afford the engineer a simple method of measuring the relative proportions in any part of a heap of concrete. If, for instance, a small quantity of concrete be placed in a tall glass vessel full of water, shaken up, and allowed to settle, three distinct layers of sediment are formed. The stones or gravel settle immediately, then follows the sand, and after a much longer period—about ten minutes in a vessel twelve inches high- the cement forms another well-defined layer. The depth of these layers varies as the amount of the respective materials present; hence, a simple measurement of the depths in two samples enables us to compare the relative quantities of the different ingredients at any two parts of the heap.

In practice the application of this test may be simplified thus: Excluding the case of concrete, which is semi-liquid, and in which the coarse matter may therefore have separated from the fine, it may safely be assumed that if the sand and cement be properly mixed the coarser parts will be also mixed; since the time required to mix uniformly increases as the grain becomes finer.

INSPECTION AS TEST OF MIXING.

Two special tests have been made, to which attention should be drawn The first was directed towards determining what was the true value of inspection alone as a test of concrete mixing. For this purpose a sample of mortar of the proportions cement 1, sand 2, was made; beside this was placed another having cement 1, sand 2½, but no difference could be detected by eye. The result was the same with cement 1, sand 3, and it was only with cement 1, sand 3½, that any difference in appearance could with certainty be detected. On applying the sedimentation test to these samples the difference in strength between 1 in 2 and 1 in 2½ was easily observed. It is therefore quite clear that inspection alone—the test which is ordinarily applied—is not sufficient to determine whether concrete is properly mixed or not.

HAND-MIXING.

The second test was one of hand-mixed concrete, turned twice dry, twice wet, on a London works of a reputable contractor.

Seven tests were made of different batches, and uniformity found in one only. The following figures show the percentage variation in the amount of cement in different parts of each batch :—

	Per Cent.
Batch No. 1	4
,, No. 2	7
,, No. 3	15
,, No. 4	0
,, No. 5	24
,, No. 6	15
,, No. 7	17

All batches, except No. 5, were mixed in the author's presence, or that of the foreman or engineer. No. 5 was mixed by the men alone, without supervision. It would therefore seem that when concrete is mixed by hand it may not be of uniform strength, and that to bring the weakest parts up to the strength required an excess of concrete must be used equal to at least 10 per cent. more than if uniformity of mixing could be assured. Turning twice dry and twice wet is not considered sufficient by most engineers to give a proper mix. On the other hand, as in the case referred to, this amount of mixing was permitted, relying upon the handling which the concrete subsequently received while filling into skips and placing in the work to complete the mixing. There is, however, a fallacy hidden here, because concrete is mixed in fairly large batches, whereas it is deposited very often in barrow-loads; this results in good mixing of each barrow-load, but not in any certainty that the proportions in all the barrows will be the same, since the concrete may be taken from different parts of an improperly mixed heap. It is hardly necessary to say that on even a small work using, say, one thousand tons of cement, a saving of 10 per cent. of this would be well worth making. By the use of a proper mixing machine, effectively used, this saving can be made. It is not impossible to get uniformity by hand-mixing, but the amount of supervision required makes it *practically* impossible.

Mixing machines vary greatly in their ability to mix, and also require supervision in their working as well as hand-mixing.

The author showed an indicator, which was designed by him for use with batch concrete mixers, and is intended to indicate to the attendant when the mixing operation is complete. It consists of a modified revolution counter, in which a worm and worm wheel operate an index which shows on a dial revolutions of mixing drum or paddles. The cycle of operations is as follows :—

1. On opening the charging gate of a machine to admit a batch, the index drops to zero.
2. When the batch is in the machine, the closing of the charging gate causes the index to commence revolving round the dial.
3. When the index has reached a predetermined point (at which for convenience a movable pointer may be clamped) the batch may be discharged.
4. An independent counter registers the number of batches mixed.

The President, before the opening of the discussion, read two letters from members who were unable to attend.

Extract from letter from Mr. Alban H. Scott, M.S.A., Member of Council C.I.

"The paper contains a great deal of useful information, much of which confirms a test which I have previously carried out on similar lines.

"Regarding the author's definition of the words 'stone' or 'shingle,' 'sand' and 'mud,' in the first place such terms may be applicable and useful from a geological point of view, but when the subject is being considered under the heading of 'Practical Application,' such terms may be most misleading, as in the actual work these terms are bound to be used by all classes from navvies up to consultants, and the three definite words, 'stone,' 'shingle' and 'mud' are open to very great misunderstandings between the various grades of men employed on the work.

"The author defines that 'grains over 1-10th in. dia.' should rank as 'shingle,' while grains finer than this would rank as 'sand.' In the R.I.B.A. Report on Reinforced Concrete 'sand' is defined to a certain extent, and it is taken up to a material which will pass 3-16th of an in. mesh.

"In Messrs. Scott and Fraser's Specification on 'Reinforced Concrete' work, published in 1911, sand is defined as 'all materials that will pass ¼-in. mesh and are retained on 1-50th in. by 1-50th in. mesh,' this latter definition being adopted by the Concrete Institute in their Report on Testing.

"'Shingle' is not a nice term to use for practical work, the two terms generally used being aggregate and coarse material. The term 'shingle' is very loose.

"The author suggests that 'mud' should be taken as all material which is less than that giving the critical diameter. The use of the term 'mud' for concrete material opens the door to a very grave misuse in practical work. It has been stated in the past that a little clayey matter rather increases than otherwise the strength of concrete. This statement, however, must have been made upon imperfect data, as it entirely depends upon whether the clayey matter has any cementing properties, and most of the materials of this description found, at least in this country, have no cementing properties.

"Clay, where it forms a coating on the aggregate or is a free agent, is most detrimental to the quality of concrete. With regard to the excess of water in concrete, this matter has been very thoroughly investigated, and in the Concrete Institute's Tests Report it will be found that the results are dealt with as to dry concrete, and further in a paper given by the writer before the Society of Architects last year.

"Regarding the mixing of concrete, this is done at the present time in the most haphazard way, and the perfect mixing machine has yet to be arrived at."

Extract from letter from Mr. Frank J. Gray, Assoc.M.Inst.C.E.

"The separation in a test-glass of water of a sample of newly-mixed concrete into measurable layers of sand and cement and a measurable residue of ballast, is a test which can be used on works with confidence, and—what is most important—quickly enough to correct any variation from specification as the mixing proceeds.

"The conclusions which the author arrives at from his experiments are very helpful in understanding the weakening of free concrete placed under-water, and the detrimental effect of using an excess of water in mixing concrete. The differentiation between mud and sand by their rates of settlement referred to a datum line, is a good one.

"I would like to ask the author whether he agrees that if particles of mud and sand be allowed to enter a tube of water at rates inversely proportional to their rates of settlement in water, such particles of sand and water would reach the bottom of the tube at the same time and form a mixture?"

DISCUSSION.

Professor Henry Adams, M.Inst.C.E., M.I.Mech.E., M.S.A. (Vice-President Concrete Institute, etc.) : Speaking of the position of concrete in water, the author said that the water separated the materials. It seemed as if they separated entirely, but he imagined that the concrete would go down to a great extent as a single mass. When it is put into water in bulk it would retain, perhaps not its cohesion, but its position, much more than the author seems to imagine.

He did not think water could percolate sufficiently to separate the mass into different sized particles, and deposit it in distinct layers. The depositing of concrete through water was at one time very constantly done by civil engineers in the construction of harbours and breakwaters.

The test given in the paper is a very simple and useful one to the engineer in charge of reinforced concrete work. In a very few minutes he can tell very closely what proportions are being actually adopted. It might also be applied to lime and sand in builders' mortar. That is always the difficulty, and many law cases have been brought as to the quality of mortar in a building. This test might possibly apply to that. The indicator for machine mixing seems also to be very good. It seems absolutely necessary to get cheap mixing of the materials, and a few trials to indicate the number of turns would give great facility to the proper execution of the work.

Mr. C. H. Colson, M.Inst.C.E., M.C.I., in referring to Professor Adams's remarks as to concrete work under water, said that of course what the author had written did not apply to concrete work under water as it is generally understood by engineers, and he imagined that what was being referred to really was rather experimental work of putting concrete under water with the intention of separating it. As a general rule, when putting concrete under water, it is put down in a big skip, and this skip is put down on to the bottom before it is opened, and there is no actual fall of the concrete through water at all. The doors are opened and the concrete settles down at once in a big mass.

For instance, he was at the present time putting down a good many thousand yards in three-yard skips. They go down on the bottom, and then open automatically, and the material

settles down as a big mass. There is washing of the top surface due to wave action, but there is very little washing due to the water coming through the concrete.

With regard to the discs falling in the water, it rather occurred to him that the reason they took up the position they did is simply a balance between force of gravity and the resistance of the water to the falling of the things; that is to say, if you could ensure the disc, or whatever it was, being kept in the upright position, it would drop at a very much greater speed, but slight irregularities on the bottom tend to start a delaying action.

Mr. E. Flander Etchells, F.Phys.Soc., M.Math.A., A.M.I.Mech.E. (Member of Council C.I.) : The paper will be particularly useful in cases of dispute as to whether concrete is clean or whether sand is clean, and, also to settle that much debated question as to what thorough mixing is.

It will also tend generally to obtain better mixing of concrete. The general practice now is to lay down concrete very gently, and to be very careful not to ram it so as to force all the lower contents to the top, and we recognise even balance mixing machines, but really sorting machines, where the concrete is sorted out of the different layers.

With regard to the question of the size of sand, some mention has been made of the R.I.B.A. Report, but it should be recognised that the size of the mesh of a sieve is not necessarily intended to represent exactly the size of the largest grains. The question has been raised in more places than one as to fixing a smaller size as the upper limit for sand, but those who have had large experience of the actual work are well aware of the fact that, if sand is to flow readily through a sieve, it is no good having the sieve just the exact size of the largest sand this is to pass, but there must be plenty of margin for rapid and economical working.

Regarding the author's statement "that the velocity of settlement varies directly as the square root of the specific gravity of the body minus the specific gravity of the liquid in which it settles," that is true, but it is ambiguous; and the ambiguity is not the fault of the author, but the fault of the English language, and it occurs wherever we try to put a mathematical expression into words. For example :

$$\frac{\sqrt{(S-L)}}{\sqrt{(S-L)}} = \frac{d}{t} = \frac{f}{s}$$

s is the specific gravity of the solid body; l is the specific gravity of the liquid. This is the square root and the specific gravity of the body, minus that of the liquid in which it settles. (Illustrating.) This also is the square root of the specific gravity of the solid, minus that of the liquid in which it settles. The fault is we are short in the English language of something to indicate these values, and he did not know whether it might not be advisable for the author to put the expression in brackets behind the written words, since the written words used are not clear.

He also would like to join the previous speaker in asking how the size of the particles was ascertained. 1-20,000th part of a square inch is very small, and it would be interesting to know by what means it was ascertainable.

Mr. J. E. Hobbs: With regard to depositing concrete under water, he entirely agreed with the suggestions put forward by Mr. Colson, that especially when depositing in big lumps, that is two or three cubic yards, the bulk of the mass deposited at one time is not in any way influenced by the water, especially if the skip or the box lowering the concrete is carefully manipulated.

With reference to the author's remarks as to excess of water in concrete, there is also the lack of water in concrete to be considered, especially nowadays when machine mixing is used. When mixing concrete, especially in a machine, it is just as detrimental to the concrete to be too dry as it is to be too wet.

This leads up to the possibility of adopting a standard of saturation of concrete. Given a certain definite class of aggregate, it appears there should be a definite amount of water to be added when mixing a batch, whether when mixing by hand or in a machine, and he did not think any attempts had ever been made to standardise the amount of water put into the concrete, and suggested it might be worth while finding some point of saturation giving concrete of such a consistency that the tendency to disintegrate when being placed in a tank is to a large extent eliminated. With reference to concrete mixing, especially in machines, this is an entirely different proposition to mixing by hand. In mixing by hand, the practice has been in the past to turn over so many times dry and then so many times wet; but in machine mixing there are engineers at the present time who specify or try to enforce mixing in a machine, first dry and then wet. It is an absolute fallacy.

Mr. H. J. Harding said he had had considerable experience in sand washing, having washed something like 1,000,000 tons. He noticed that what the author stated on this point was very accurate.

As to the question of the size of sand, mentioned in one of the letters, he made his definition of sand about a $\frac{3}{16}$-in. round hole washed through; but it must be understood that washing sand through a sieve is a totally different thing from drifting it, and he had always found a $\frac{3}{16}$th round hole is practically the same as a $\frac{1}{8}$th square mesh, because a square mesh has a longer angle at the corners, so that sand washed through a $\frac{1}{8}$th square hole and sand washed through a $\frac{3}{16}$th round hole is practically the same, but it would not be the same as sand sifted through in the ordinary course on a job. When sifting sand, the moisture it contains must be taken into consideration. If it were very dry, it would sift very much more easily. The statement that sand should not be considered sand if it went through a 50 mesh was a great mistake. This also applied to concrete, because it means throwing away the most important part of the aggregate, and for this reason : if it is wanted to defeat percolation in cement that is finer sand, and finer sand to go down to a sieve of 100 mesh each way; 100 meshes to the inch would be most useful to stop percolation with cement. He had tried this and knew it was correct, and therefore the Concrete Institute's definition ot sand as below 50 should be reconsidered.

Professor Robert H. Smith, Assoc.M.Inst.C E., etc., said he rather demurred with Mr. Alban Scott to the author's use of the word "mud." It seems that on this subject it is very desirable, and perhaps necessary, to make careful distinction between those substances which contain any proportion of material that will actually go into solution in water and those that will not—that can only be held in water by suspension; and what is ordinarily called mud usually contains a considerable quantity of matter that may go into solution in water. The phrase "mud" may be very useful in this connection but it ought to be defined perhaps as material containing matter that will go into solution in water, and either "flour" or "dust" used for the stuff that Dr. Owens has called mud.

Mr. M. Noel Ridley, Assoc.M.Inst.C.E.: With reference to the amount of water in concrete, he believed in a medium amount of water, but considered an excess of water, unless it is too great, is better than having really too dry a concrete, and that there should be no ramming, or next door to no ramming, of the concrete; ramming is a very bad thing.

As to mixing the concrete twice dry, twice wet, in all his ordinary work he carried out this very specification, and with the happiest results, so that for ordinary work that specification need not be departed from.

In depositing concrete in water, he did not think there should be so much fear of the separation of the particles in depositing under water. He had recently put down in 12 ft. to 14 ft. of water a considerable amount of concrete. No skips were used, but shoots with open ends. The shoots were placed on the ground and then the concrete was put in, and when properly filled up the shoot was raised and moved about to the different parts, and the concrete was being shovelled into the shoot the whole time; and that made splendid concrete. Of course, that concrete was mixed a little bit stronger than in ordinary cases, but the results were absolutely satisfactory.

Mr. Henry Puplett, M Soc.E., M.C.I.: The author has dealt with a very important matter in treating of the mixing of concrete, because the most careful calculation, the most skilled design and the best workmanship may all be nullified by the use of improperly mixed concrete.

With regard to mixing machines, it is almost impossible to get a properly machine-mixed concrete with any mixer in which the two operations of charging and discharging the machine can be carried out simultaneously. The only safety is the employment of a type of mixer which is rendered compulsorily intermittent by the application of some definite mechanical operation for the discharging of the concrete.

Mr. T. A. Watson, M.C.I.: With regard to the idea that there is a certain definite proportion of water which should be added to the aggregate, this is not the case; there is a varying definite proportion, but it is not a definite proportion, and there is a certain amount of latitude which must be allowed, or should be allowed, to contractors by engineers in that proportion, because the dryness of the aggregate controls it in one way, the weather controls it in another; and altogether there are several outside sources, and no definite hard-and-fast rule is wanted that there is a certain amount of water that has to be put with concrete that is composed of certain proportions of ballast, sand and cement.

Mr. H. J. [illegible]: With regard to fixing the quantity of water in the quantity of [illegible] or the quantity of aggregate, engineers who consider the question should have regard to the fact that practically no two aggregates in no two places would have an accurate

measurement, and the quantity of water necessary to mix a certain quantity of concrete with a certain amount of aggregate would depend very largely upon the amount of the individual atoms composing the aggregate itself.

DR. OWENS'S REPLY.

With reference to the thickness of the cement layer, he had not had time to describe in detail the steps by which he arrived at that, but he found that when the cement settles through the water at a certain depth down below the surface it acquires what is called a surface of separation—it defines a surface quite clearly. Then, that goes on settling for another period, until a time is reached—about 10 minutes—when it ceases to contract, and it does not get any thinner than that; and there appears to be a certain amount of water which it will not lose—that is between the interstices—and that is the time to measure, and it is easy to tell by watching it when it ceases to contract.

A good deal of discussion has centred around the definition of sand and shingle. The question is, perhaps, somewhat misunderstood: Is there a difference between sand and shingle, or are we asked to give an arbitrary definition between two things? There is a natural line drawn by nature between particles above a certain size and below, and we ought to consider the things below that as sand, above as shingle.

The elimination of all particles below what passes through a 50 mesh had also been referred to, and he was very strongly of the opinion that that is a mistake. There is no reason whatever for eliminating those particles. As a matter of fact, the very finest particles, even down to 1-1,000th of an in. will act just as well as the coarser particles, and somewhat better, from some points of view, in making concrete.

One very important point referred to is the question of the porosity of concrete. It is a well-known fact that particles of uniform size, when placed in a vessel, contain the maximum amount of air space or voids. If it is wished to reduce the amount of void, it can be done by introducing smaller particles which will fit between the larger ones, and this can be done to infinity until it is solid. The removal of those little particles which pass the 50 by 50 mesh is leaving vacancies which must be filled by cement or left empty. If they are left empty, porous concrete is the result.

There has been some misunderstanding with reference to the deposit of concrete under water. Professor Adams, Mr. Colson, and several other gentlemen have referred to it. What it was intended to convey was that small pieces of concrete must not be dropped and allowed to settle through any depth of water, such as throwing concrete into a trench with a shovel. Of course, it is perfectly sound practice to put concrete through water in a big skip which can be opened when it has reached the bottom or through a shoot if the water is sufficiently shallow; there is another method adopted in trench work: that is to put the concrete in above the surface, then put fresh concrete on the part above the surface, and it will push the other along so that it will not fall through the water.

As to Mr. Etchell's remarks on the gauging of sand by a sieve. There is rather a curious point; it is surely perfectly well-known. The particles of sand which fall through a sieve very often fall end-wise, that is measuring the minimum diameter; in fact, if the particles which have passed through a sieve are put on the stage of a microscope and their diameter measured it will be found that it is maximum diameter which is being taken.

Mr. Ridley referred to the lack of water being as bad as having too much. As the Chairman has very wisely said, there must be neither too much, nor too little; there is a proper mean. If there is too little the concrete gets sticky, and you cannot mix it; while if more is used porous concrete results.

It ought also to be made quite clear that it is utterly impossible to fix the amount of water to be added to concrete, because there are several things which govern this point. The amount of water which concrete should contain can be fixed, but that is quite a different thing. The amount which is to be added depends upon the amount which is already present in the aggregate and also in the porosity of the aggregate, also upon the shape of the particles, and upon various other things, but it is impossible to tell what that should be except by judging from the appearance of the concrete after it is made.

Professor Smith referred to the difference between mud and sand. Of course, the word mud requires to be accurately defined, to base any statement upon differences between mud and clay or mud and sand, but in the ordinary meaning of the word it does not seem necessary that one should consider that mud is something which is matter, which can go into solution. The author concluded by answering some other remarks of Professor Smith and on the evils of over mixing, and the meeting then concluded.

STEEL FRAME BUILDINGS IN LONDON.

By S. BYLANDER, Chairman, Junior Institution of Engineers, M C.I.

The following is a short résumé of Mr. Bylander's Paper read before the Institute on February 13th, 1913, as far as it deals with his views as to steel-frame buildings generally. As the three buildings particularly described in this Paper—viz.: The Ritz Hotel, Selfridge's Stores, and the Royal Automobile Club—have been fully described and illustrated in former issues of our journal, that portion of Mr. Bylander's Paper is not reported here.*

IN opening, the author remarked that he believed this was the first paper on the subject of steelwork construction which has been presented, and he was glad to see that the Concrete Institute had decided to invite papers and discussions on subjects within a broader range—namely, upon *structural engineering* generally—instead of confining them to the particular aspects of *concrete and reinforced concrete* only.

In this paper it is not proposed to give a comparison of advantages and disadvantages of steel buildings and reinforced concrete buildings, but to put forward a few factors which are of importance to the designer. The reinforced concrete engineer and the structural steel engineer have many interests in common, and their co-operation is an advantage. The advancement of knowledge of the use of different materials is essentially necessary before any progress can be made.

The question of whether reinforced concrete, steel, or other material shall be used in a particular building must be left to the decision of the architect, engineer, or estimator, who has made a careful study of the requirements in each case.

There is not yet any golden, general rule to determine when and where a particular material is most suitable. The only rule which is possible of application is *use each material to its greatest advantage.*

Good engineering judgment, based on practical experience, combined with careful design and accurate calculation, is required to obtain the best results.

STEEL FRAME BUILDINGS IN LONDON BEFORE THE YEAR 1909.

The use of steelwork for the skeleton of the building before the passing of the L.C.C. General Powers Act of 1909 was relatively small. Considerable progress has taken place during the last ten years, and it is very interesting to compare the construction used ten years ago and that which is now gradually being introduced.

He believed the Ritz Hotel was the first building in London to be designed on the cage construction principle, about the year 1904. The usual construction at that time was to employ some steelwork in the internal part of the building only, or to carry the external wall at the first floor level on steelwork to permit large shop windows, and sometimes steel pillars were used to strengthen external walls. Where fire-resisting buildings were required, the floors were usually constructed with solid plain concrete, carried on steel beams 2 ft. to 3 ft. centres, but very little precaution was taken for stability or protection against fire for the individual steel members. The pillars were generally made in one-story lengths, with caps and bases.

At that time there were no recognised standard sections, but each mill rolled their own particular shapes. These conditions made it very difficult for the structural engineer to select the most economical sections, and a very great improvement has taken place through the standardisation of sections.

L.C.C. 1909 ACT.

The passing of the L.C.C. General Powers Act in 1909 had a very good effect upon the method of construction. It is to be regretted that the Act does not applv to buildings designed according to the old Act; nevertheless, the introduction of recognised standard stresses and a general method of design and supervision will tend to simplification and economy in design and fairer competition and safer structures. No Act can be satisfactory to all, but it would have been better if the building code had taken the form of regulations by the London County Council instead of an Act of Parliament. All regulations in connection with engineering must necessarily be revised periodically as the science and practice advances, and it is to be hoped that at a not too far distant future this Institute will urge the London County Council to obtain powers to issue new regulations in a more complete form.

* Vol. I., No. 6. Vol. IV., No. 1. Vol. VI., No. 3.

ECCENTRIC LOADING.

Stresses from eccentric loads are always produced on pillars either on account of imperfect bearing under the base, in the joints, or on the cap; these may be called accidental eccentric loads. Loads carried on brackets, or otherwise placed eccentrically to the axis of the pillar, may be called intentional eccentric loads. The loads placed on the cap of the column should in most cases be calculated as eccentric loads, although at first sight it may appear that the load is placed concentric. On account of the deflection of the beams a bending moment is produced on the pillar, and allowance should be made for this when fixing a safe stress for the pillar.

Another factor affecting the safe stress which is of very great importance is the question of the *inset* or edge distance of the section.

More consideration should be given to the question of reduction of strength of the pillar section by rivet-holes. A safe stress for a direct load for a pillar should be set so low that an increase of 10 per cent. due to intentional eccentric loading will be permitted, and where the eccentric load is greater, the sections should be increased correspondingly to 90 per cent. of the eccentric load only. By this means detail calculations for very small eccentric loading will not be required, and the engineer who calculates everything carefully and in detail will not be placed at a disadvantage as compared with those who do not go into details so completely. The maximum direct stress should be set so low that a slight bending should not necessitate increase of section. On the other hand, he thoroughly believed that pillars should be calculated for eccentric intentional loads.

ACCURACY OF CALCULATIONS AND DRAWINGS.

The chief point in connection with satisfactory and economical design is accuracy of drawings and calculations. Higher stresses can be used when all loads and stresses are accurately calculated, and when drawings are made so complete that no alterations, or very slight alterations, are necessary in the final work, and when the work is well supervised.

The economic use of materials necessitates stressing same as high as is consistent with safety, and in order to use high stresses great care and accuracy must be exercised. These rules apply equally well to steelwork and reinforced concrete. The plans for a structure should be laid out with due consideration to the employment of the materials intended. Spacing of pillars, depth and span of girders, spacing of beams, etc., affect the cost to a very considerable extent. It is hardly realised how much extra it costs to make the beams very shallow; very often double the material is put in beams because the original plans have been made with the assumption that shallow beams should be used in order to obtain greater head room. It can be said generally for steelwork as well as reinforced concrete work the depth of beams of about 1-12th to 1-15th of the span is economical, and the spacing of pillars from 15 ft. to 20 ft. is also satisfactory. It is still more economical to place the pillars closer in one direction than the other in order to use only primary beams and no secondary beams. This, however, is seldom possible in ordinary buildings in London.

SURVEY OF SITE.

The first thing to start with in preparing a set of working drawings for a building should be to have an accurate survey of the site, from which to prepare dimensioned plans for walls and pillars. Unless accurate dimensions are obtained at an early date, the plans cannot be made correct to scale, which obviously will affect the accuracy of the calculations for loads and bending moments.

SIMPLIFIED CALCULATIONS.

The author has adopted the practice of using one sheet of paper, quarto size, for the calculation of each piece. Each piece has a mark or identification number, and this is used as the sheet number on the calculation sheet. This method will facilitate keeping of records, and avoid mistakes in connection with the alterations. It also permits of using printed sheets, and thus reduces the labour of repeating sketches and writing. He further believed that the adoption of pounds as a unit of weights instead of hundredweights or tons is an advantage, for the reason that in close calculations one must deal with smaller unit weights than hundredweights, and decimals of hundredweights and tons are not desirable. If pounds are used, the weight of

materials or the assumed superload can easily be varied a relatively small amount to suit requirements. The calculations of the dead weight of floors can be conveniently made as follows: Assume reinforced concrete weighs one pound per square inch of section of beam or slab per foot run, thus, the slab 6 in. thick and 12 in. wide would weigh 72 lb. per foot run, and an 8 in. by 4 in. concrete beam 32 lb. One pound per square inch per foot run is equivalent to 144 lb. per cu. ft.—which is for all practical purposes a fair average weight. The result is that the weight calculated can be used directly as load to be carried without transferring same into hundredweights or tons. Pounds are very suitable for unit weights and loads, but the pound is too small a unit for big loads. He had, therefore, adopted 1,000 lb. as a unit for big loads, and he called 1,000 lb. one kip, derived from kilo (=thousand) and p (=pounds). To transfer from one unit to the other only necessitates moving the decimal point three places. A great amount of labour has been saved and mistakes have been avoided. The bending moment may be expressed in kips and inches, and the unit length of one inch is therefore used in the calculations throughout.

The stresses are generally given in pounds per square inch, except in the case of big areas, such as brickwork and ordinary concrete foundations, etc., where the pressure is given in kips per square foot.

DRAWINGS.

The drawings required for the steel structure may be divided into three classes: (1) plans, (2) constructional details, (3) shop details.

Plans.—The plans should show the general design, position of pillars and beams, and give all main sections and mark of every separate piece that is sent to the site.

Constructional Details.—Constructional details are required to illustrate and make clear the connections, riveting, machining, and all general requirements, the relative dimensions between steelwork and stonework, etc.

Shop Details.—These are made for use in the shop, and should show every dimension required to make the piece complete, and should not be merely constructional details leaving the accurate positions of rivets to be determined by the workmen in the shop.

It is of equal importance to have clear constructional details and shop drawings as to have carefully designed general plans. Unless the shop details are carefully worked out for dimensions given on the drawings, showing rivet spacing, sizes of rivets, edge distances, accurate position of open holes for field rivets, notes of special requirements such as cutting, machining, countersinking, etc., it is not possible to obtain satisfactory work on the site.

All details should be completed in the office by the draughtsman and properly checked before the orders are issued to the shop. The checking cannot be done so effectively in the shop as is possible in the office, and the cost of making alterations of the steelwork on the site is much greater than the cost of checking and correcting the details in the office.

PROGRESS OF WORK.

Systematic working throughout will prevent mistakes and difficulties, and procure satisfactory work and speedy erection.

Order Lists.—When the shop drawings are finished mill order lists are prepared, giving section and size of material required, and the material is ordered from the rolling-mills. Then shop order lists are prepared for all duplicate work such as cleats, brackets, and stiffeners, and these order lists, together with the shop details, are sent to the shop and the work is put in hand.

During the progress of rolling and manufacture an inspector supervises the work, tests the material, checks all dimensions from the detail drawing, inspects the finished member, and approves or rejects same before it is sent to the site for erection. The inspector sends weekly reports to the engineer giving the marks of the pieces, stating: (1) material rolled, (2) pieces assembled, (3) pieces finished, and (4) pieces sent to site. In this manner the engineer can supervise the satisfactory progress of the work, and take precautions to avoid delay. The erection is a very simple matter if the pillars are set in accurate positions according to the pillar plan and the walls built to the dimensioned plans and details. The erection can proceed with great speed, as all pieces are made to exact dimension, and must fit when delivered, care being taken in making the design to allow for easy erection and the minimum amount of field riveting.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE EXTENSIONS TO ELECTRICITY WORKS, HULL CORPORATION.

THE works described below include new engine-house and boiler-house with overhead coal bunker, now in course of erection at the Sculcoates Lane Electricity Works of the Hull Corporation.

The engine-house, which is being erected at the end of the existing engine-house, has a width of 65 ft. between walls, a height of 26 ft. 6 in. to eaves, and a length of 107 ft., with provision for future extension.

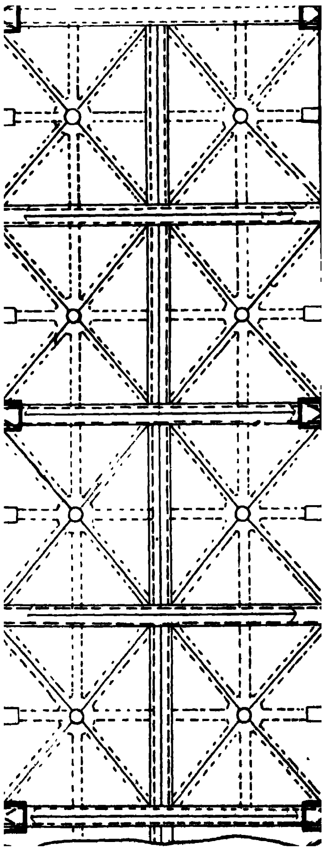
The turbo and condenser foundations are built of mass concrete upon a cluster of pitch pine piles, with basements running each side at a level 12 ft. 6 in. below main floors. The floors, which have been calculated to take a dead load of 3 cwt. per sup. ft., consist of 6-in. reinforced concrete slabs resting on cross-beams 15 in. by 20 in., forming girders of the usual T-section, and are reinforced by ¾-in. round rods with ¼-in. stirrups to take up excess of shear. The sides and gable are composed of curtain walls 6 in. thick below and 5 in. thick above floor level, reinforced by ½-in. rods vertically and horizontally at 6-in. centres below and 18-in. centres above floor level, with footings 5 ft. by 1 ft. 9 in. with ¾-in. rod reinforcements.

The walls are stiffened by pilasters 24 in. by 12 in., each pilaster containing a 12-in. by 6-in. R.S.J., which joists at the side receive the shoes of roof trusses; while at each alternate pilaster there are piers 14 in. by 24 in., with ¾-in. vertical reinforcement and ¼-in. wire lacing, carried to a height of 19 ft. 4 in. to receive longitudinal girders for travelling crane.

The boiler-house, which has a span of 100 ft. and is 90 ft. long, with provision, as in the case of the engine-house, for future extension, is made up of a central basement 25 ft. wide by 10 ft. 6 in. high, with boiler foundations on each side and main boiler-house floor above, with overhead coal bunker 34 ft. from floor level.

The roof is composed of steel lattice girders secured at the outer walls to the R.S.J.s previously mentioned, and on the inner side by Lewis bolts to the sides of the coal bunker.

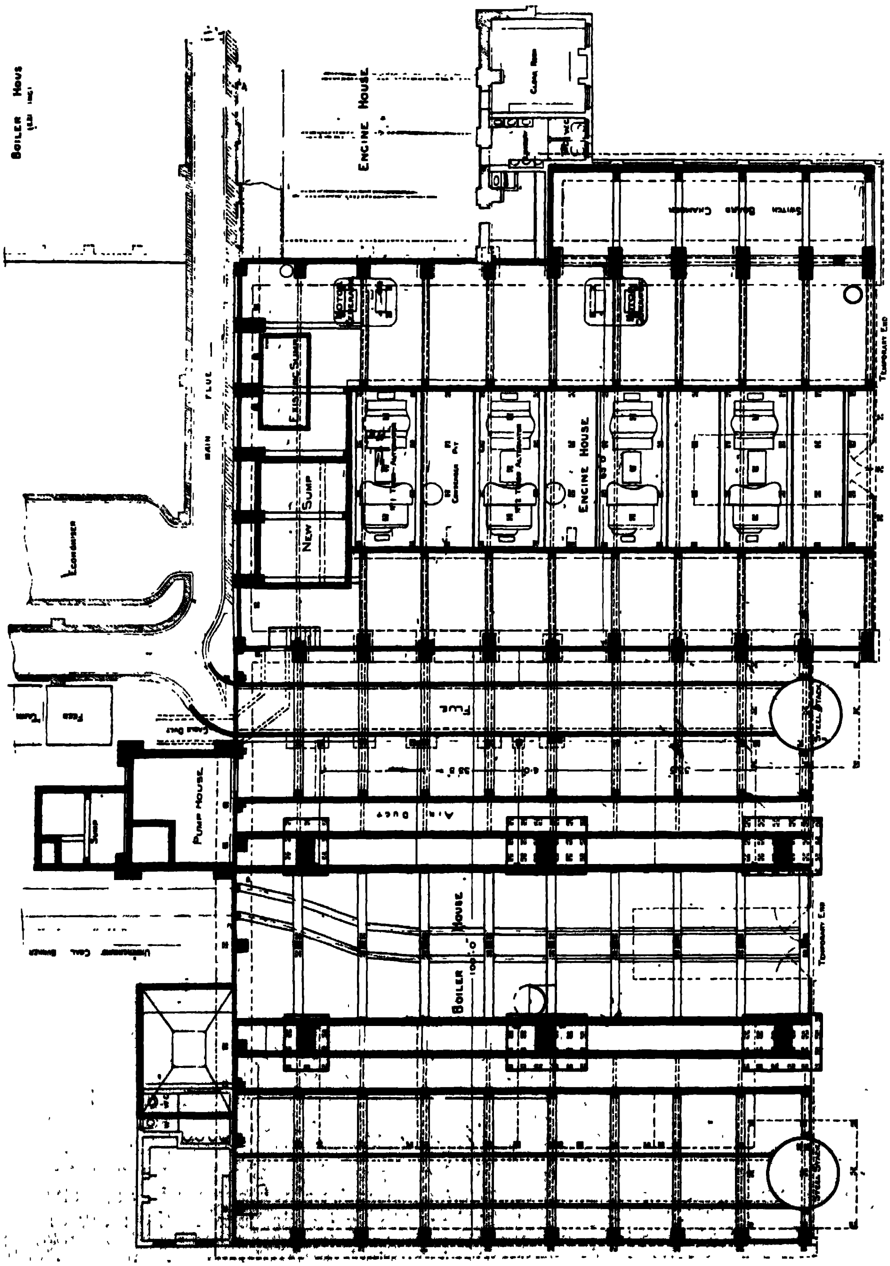
The floors are made up of reinforced concrete slabs 7 in. thick on the main floor and 6 in. thick in the basement, resting upon crossbeams 18 in. by 24 in., and the cross-



Plan of Coal Bunker.

ELECTRICITY WORKS EXTENSION, HULL CORPOR

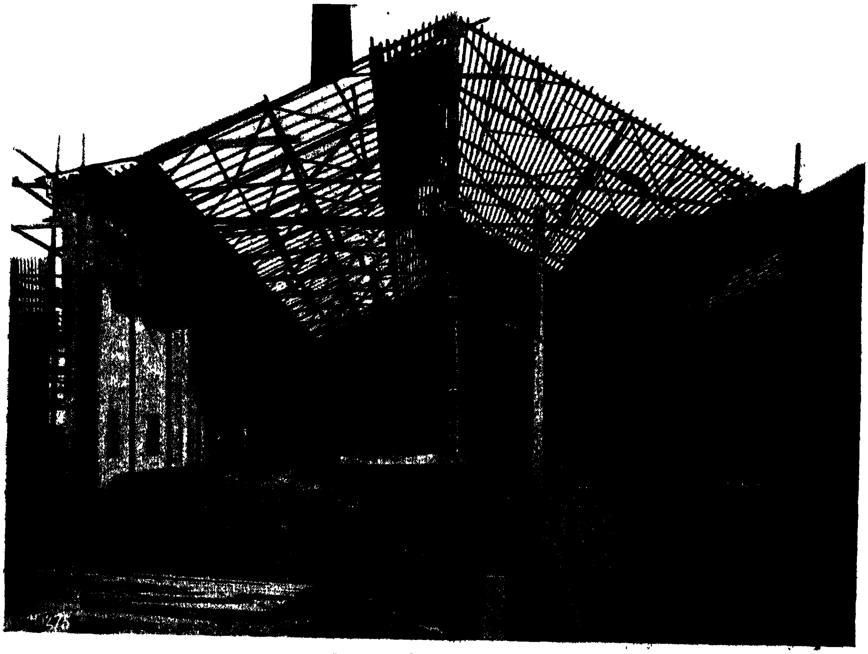
beams are reinforced in a similar manner to the engine-house, with additional longitudinal beams in the top floor to carry railway, which will be used temporarily pending the complete installation of mechanical stoking.



Plan.
Electricity Works Extension, Hull Corporation.

The boiler foundations and flue are made up of 9-in. concrete slabs similarly reinforced, lined with 9-in. fireclay brickwork, and carried upon crossbeams

View of Reinforced Concrete Columns supporting Reinforced Concrete Coal Bunker.

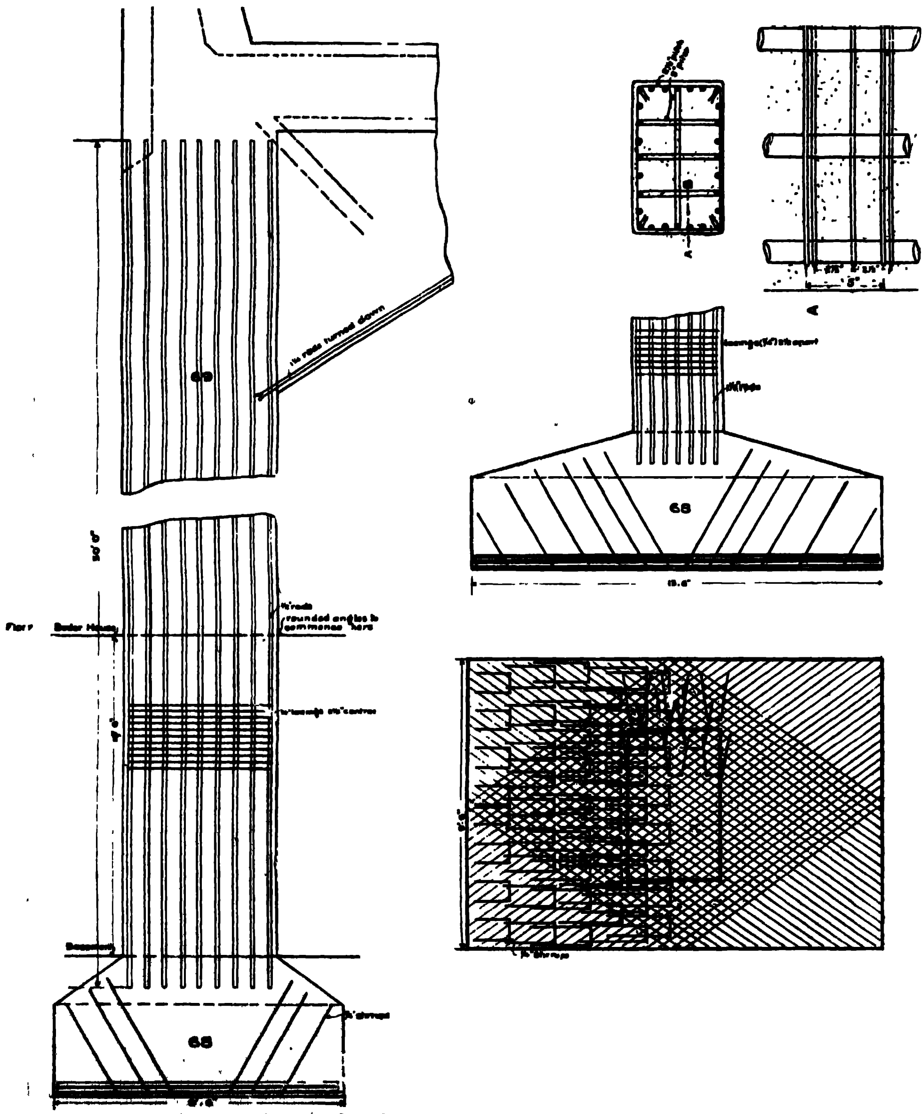


Interior of Turbo Room.

ELECTRICITY EXTENSION WORKS, HULL CORPORATION.

18 in. by 20 in., and 18 in. by 34 in. respectively, from which, in the case of the flue, they are separated by a sand joint to allow of free expansion and contraction.

The overhead coal bunker, as will be seen from the accompanying section, extends the whole length of the boiler-house, and is carried upon six reinforced concrete stanchions each 5 ft. by 3 ft. by 44 ft. long, supported upon a reinforced concrete

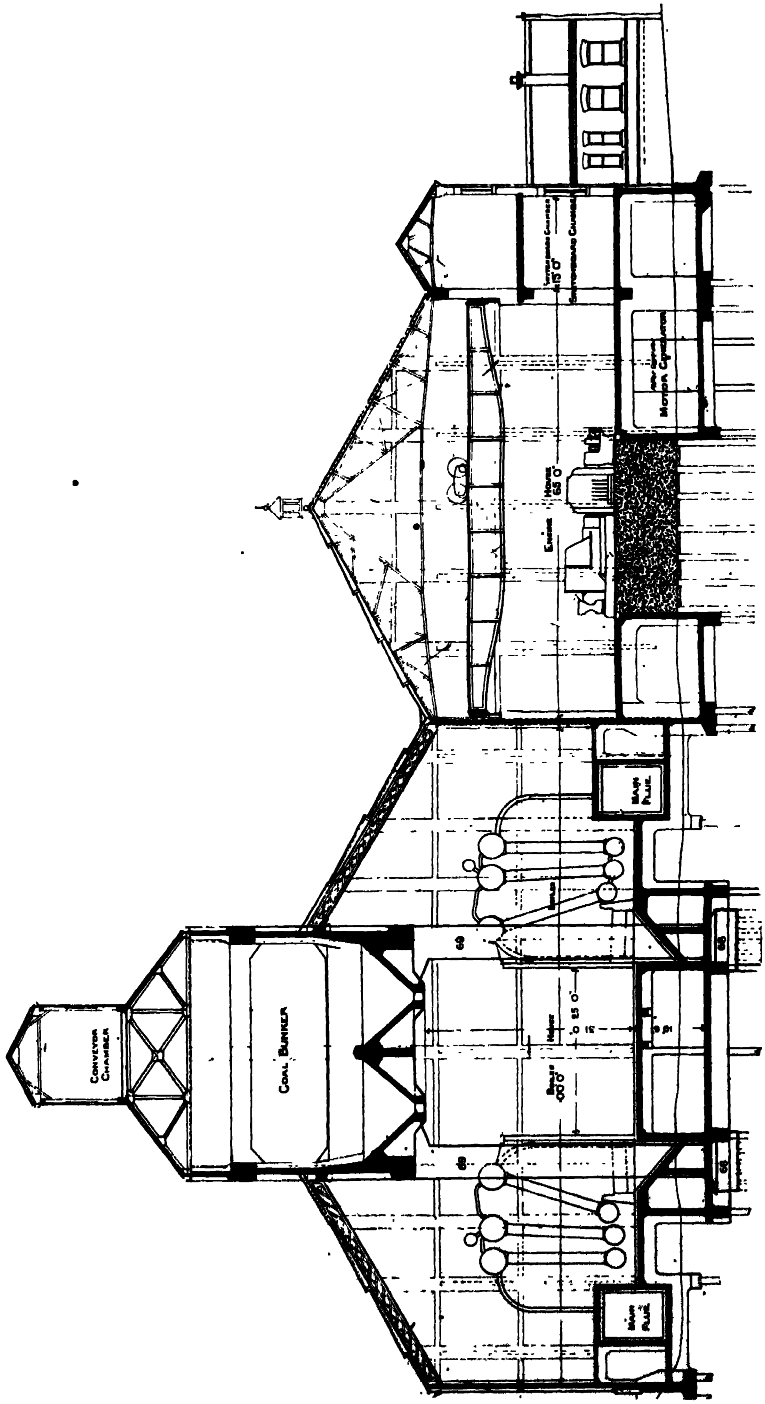


Details of Bunker Foundations and Stanchions.

ELECTRICITY EXTENSION WORKS, HULL CORPORATION.

footing, of which detail is given below, 13 ft. 6 in. by 9 ft. 6 in. by 4 ft. 6 in., reinforced by a grillage of 2-in. bulb tees with ½-in. stirrups to take up excess of shear.

These footings are carried in turn upon clusters of pitch pine piles 14 in. by 14 in. The stanchions are built of 2—1—1 shingle concrete reinforced by 28 No. 1½-in. round rods with ½-in. lacing at 2½-in. centres, and have been designed to take a maximum load of 1,012 tons.



Cross Section.
Electricity Extension Works, Hull Corporation.

The coal bunker is 35 ft. wide, 33 ft. high, and 95 ft. long, the underside being battered up at 40 deg. at gable to conveyor level, with a wood partition at the other (temporary) end.

The arrangement and the number of the supports of the coal bunker were governed by the positions of the water tube boilers and the necessity of providing an uninterrupted space between the fronts of the two rows of boilers. As only six points of support were available, the stanchions had to be of considerable sectional area. The capacity of the coal bunker is 2,000 tons.

It is formed of 7-in. reinforced concrete sides, with top and bottom booms 48 in. by 30 in. carrying over a span of 40 ft., and a central longitudinal beam 9 ft. by 1 ft. 6 in. resting upon cross-beams over stanchions and intermediately.

The slabs are reinforced by ½-in. round rods at 4-in. centres, double reinforcement, horizontally and vertically, with ½-in. rods diagonally over supports to take up excess of shear, while the booms and cross-beams are reinforced by 1½-in. round rods. The bottom of the bunker is formed into pyramidal 6-in. slab hoppers carried upon cantilevers 12 in. wide with a maximum depth of 7 ft. 6 in. from sides and cross-beams, which batter to 18-in. outlets 34 ft. from floor level.

The slabs are reinforced by ½-in. round rods, while the cantilevers are reinforced by 1¼-in. rods at top, and ¾-in. rods at bottom, with ⅜-in. diameter lacing for shear.

The top of the bunker is formed by a steel truss roof carrying conveyor chamber, 12 ft. 6 in. wide by 10 ft. 6 in. high, with steel floor, and sides formed of "Hy-rib," in which a bucket conveyor works, lifting coal into the hoppers from an underground coal bunker.

This chamber is covered with steel trussed, slated roof, with ridge 100 ft. from boiler-house floor.

Additional works comprise large underground pump chamber and drainage sump, an underground ashpit and coal bunker, and two exhaust sumps, all in reinforced concrete, with cloakroom and the usual offices.

There is also a switchboard chamber, 65 ft. long by 14 ft. wide by 26 ft. 6 in. high, along the south side of engine-house, built in reinforced concrete, but faced in brickwork to correspond with the adjoining (existing) buildings.

The foundations being soft clay upon a bed of peat, capable of bearing a load of only about 14 cwt. per sup. ft., it was found necessary to pile the whole site, 400 pitch pine piles being used for the purpose.

Owing to the nature of the foundations, large beams with low percentage of reinforcement have been favoured, as giving additional lateral rigidity.

The buildings have been specially considered in design with the view of making them as fire-resisting as possible. Except the light wood lathing for securing the slates, the whole of the roofs are of steel, and, as an additional protection, large asbestos slabs about $\frac{3}{16}$ in. thick are to be screwed to the lathing.

The whole of the work was erected to the design of Mr. A. E. White, M.Inst.C.E., City Engineer, Hull, the contractor for the reinforced concrete and builders' work being Mr. J. T. Levitt, Hull, and Messrs. E. C. and J. Keay, Ltd., Birmingham, for the constructional steelwork.

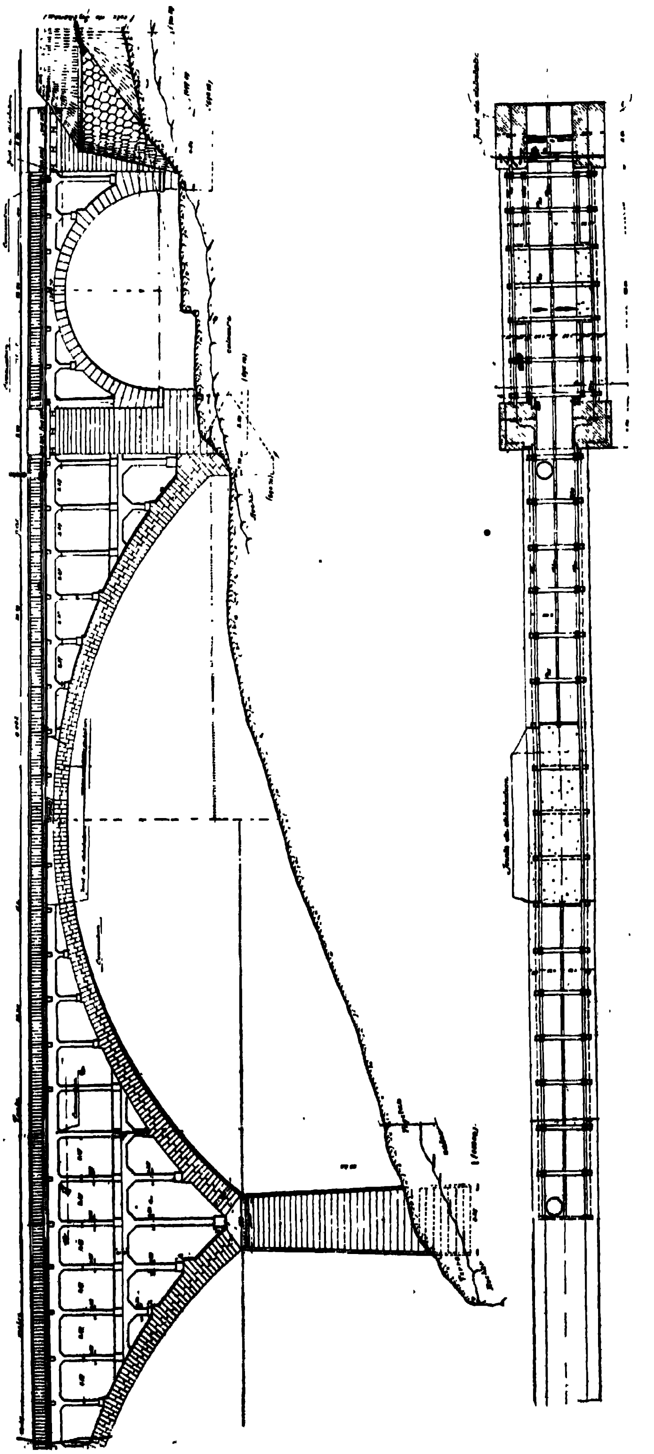
REINFORCED CONCRETE BRIDGE IN FRANCE.

The bridge here illustrated has recently been erected at Seytenex, near Annecy, in Savoy, France, by Messrs. Mazet and Limousin, Contractors and Licensees of the Coignet System at Lyons.

As shown in the illustration (*frontispiece*), this bridge spans a deep valley, at the bottom of which runs a river, and the foundations of the abutments and the piers are constructed on the rock.

This particular type of bridge is similar to the one which was erected about fifteen years ago, also on the Coignet System, at Luxemburg. It may be described as a composite structure, the arches, piers, and abutments being in stone masonry, and the superstructure being entirely in reinforced concrete.

A noticeable feature of this particular type of bridge is that it is composed of two parallel arches in stone masonry, instead of the usual single masonry arch, which is, of course, more costly and more complicated to erect. In this case the scaffolding for one of the masonry arches is shifted, after the work has been completed, and used for the construction of the adjoining arch, so that much lighter scaffolding is required than by the usual method. The two arches are connected together by the reinforced

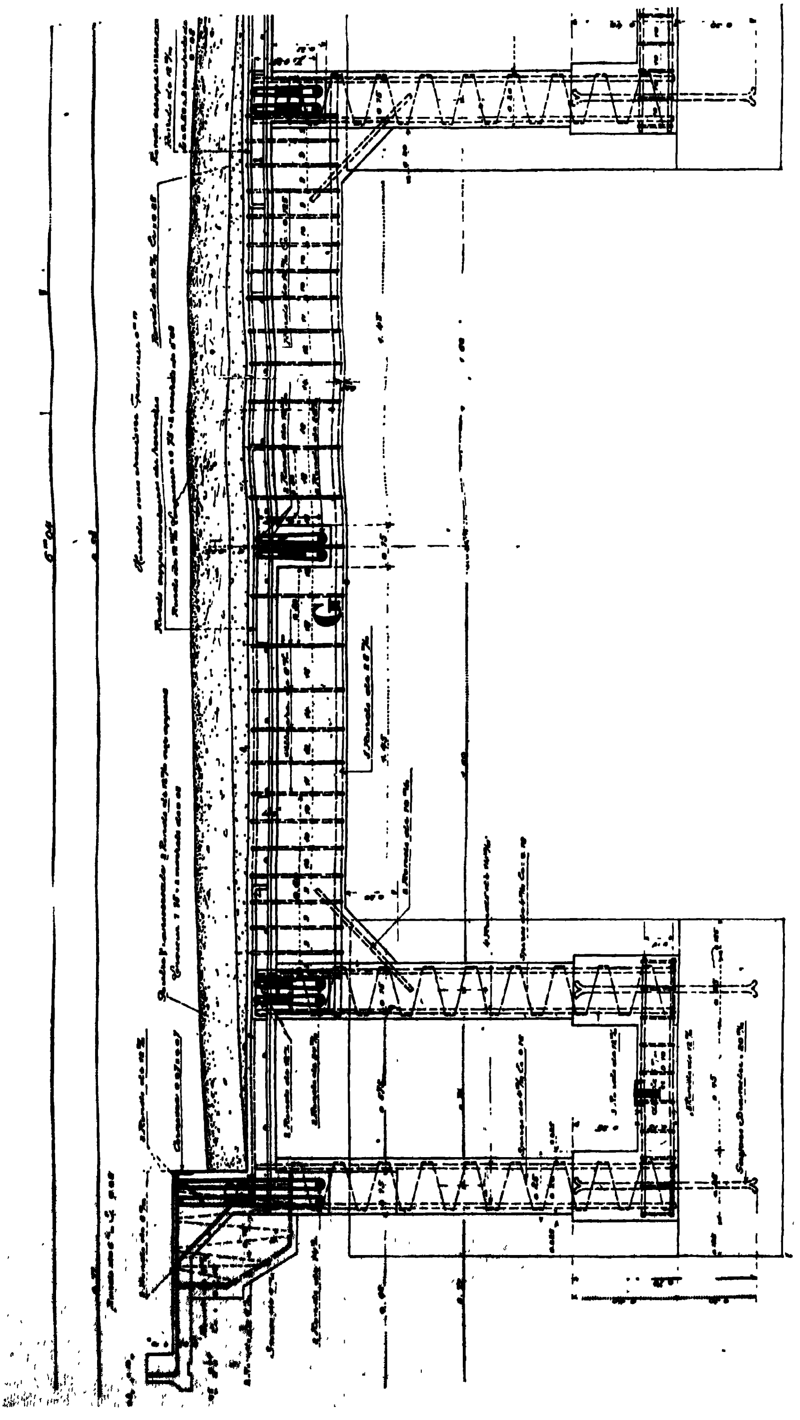


concrete superstructure, which they support. The spans of the principal arches of this bridge measure approximately 140 ft., and the two smaller arches at each end have a span of about 43 ft. The deck and the arches are calculated for ordinary road traffic, the heaviest moving load being that of a steam-roller weighing 15 tons. The principal masonry arches measure approximately 5 ft. at the springing and 3 ft. in the middle.

As stone is easily procurable in this particular district, it was found more economical to make the arches in this manner than in concrete or reinforced concrete.

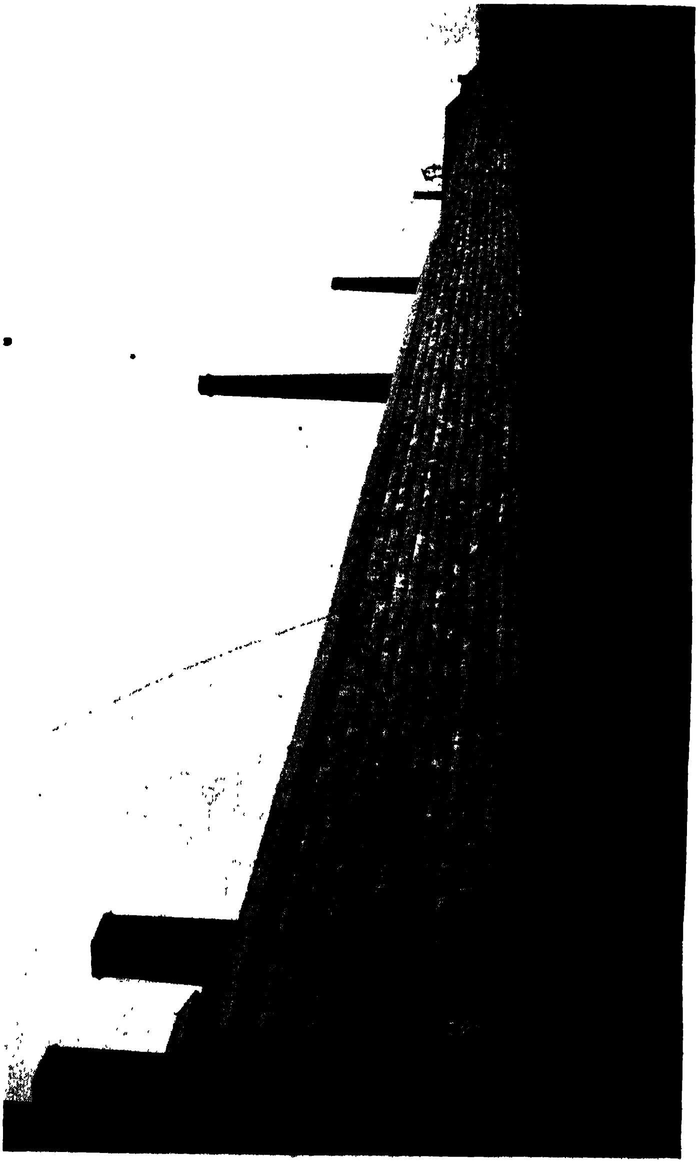
As shown in the accompanying elevation and plan, the weight of the roadway and deck is transmitted on to the twin masonry arches by means of a series of pillars. The footpaths on either side supporting an iron railing are cantilevered and supported at intervals by means of brackets. The width of the roadway is approximately 13 ft., and the total width of the bridge, including both side walks, is approximately 18 ft. The masonry arches have a width of about 4 ft., and the interval between them is about 7 ft.

The reinforced concrete superstructure, which includes



Cross Section.
Reinforced Concrete Bridge, Seytenex, France

the pillars, tie beams, and the deck, is executed on the Coignet System, which is composed of a special arrangement of round bars of mild steel. The pillars contain four bars at each corner, held together by means of spiral ties of small diameter. The longitudinal beams contain two main bars in the bottom portion working in extension, and two upper bars in the top portion of the beam working in compression, the two sets of bars being united by means of small-diameter round bars or stirrups, which are intended to resist the shearing efforts in the beams. The transverse beams underneath the floor slab, uniting the two parallel rows of pillars above the arches, and supporting also the decking, contain three bars in tension and three bars in compression, also united by means of stirrups. The decking itself, which is about 5 in. in thickness, contains a meshwork of round bars. The reinforced concrete decking is covered by means of a certain thickness of richer concrete laid to fall to prevent the percolation of water through the reinforced concrete deck, and the roadway is made up by means of about 9 in. of ordinary road metalling.



Boundary Wall
Tinplate Works, Llanelly, South Wales.

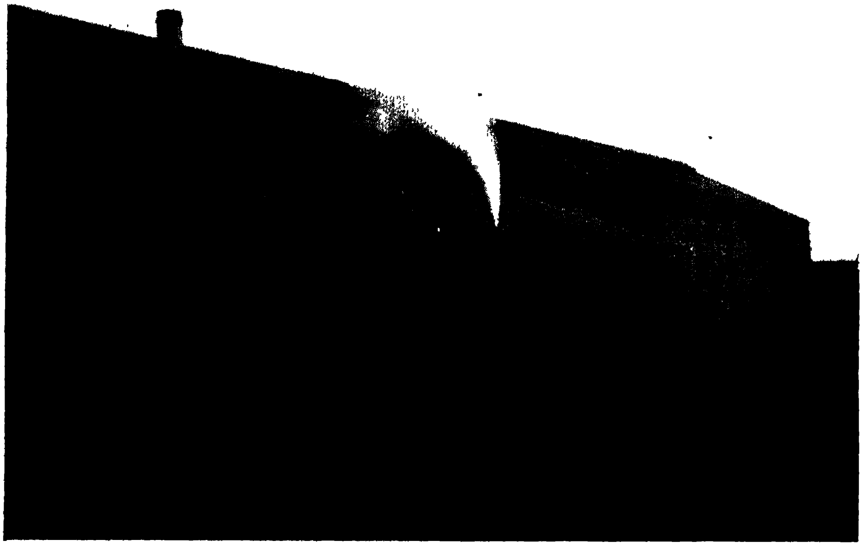
TINPLATE WORKS, LLANELLY, SOUTH WALES.

The accompanying illustrations show some works recently erected with "Winget" concrete blocks.

The main building contains a travelling overhead crane carried on steel columns. The wall panels between the steel columns are 18 ft. 8 in. wide by 35 ft. high, and are filled in with 32 in. by 9 in. by 9 in. hollow concrete blocks. 25,299 blocks were required in construction.

The workshops, pickling-house, engine-house, and tin-house were all erected with hollow concrete blocks as above, the number used being 18,219.

The photograph below shows that concrete blocks are admirably adapted for industrial purposes, and it will be noted that the walls are built "honeycomb" fashion for ventilation and the escape of fumes arising in the course of manufacturing tinplates.



TINPLATE WORKS, LLANELLY, SOUTH WALES.

The boundary wall (p. 283) was also constructed with "Winget" blocks, its length being 587 ft. and the height 10 ft.; 5,602 blocks were required for its erection, and to finish same 220 lengths of coping 32 in. by 12 in. by 9 in. were required, the latter also being made on the "Winget" machine.

Thus the total number of concrete blocks used on this contract was 49,110. The blocks were made on a "Winget" concrete block-making machine, and the concrete was mixed in one of the company's "Express" mixers. The output of blocks averaged 400 per working day. The contractor was Mr. S. E. Clay, Nuneaton, for Messrs. R. Thomas & Co., Ltd., of Llanelly, South Wales, and the architect was Mr. W. H. Walker, 12, Cherry Street, Birmingham.

NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

"Structural Details of Hip and Valley Rafters." By Carlton Thomas Bishop.

London: Chapman & Hall, Ltd., 11 Henrietta Street, Covent Garden, W.C. 72+v pp. Price 7/6 net.

Contents.—General Outline—Flange Connection—Web Connection—Notes on Other Cases—Derivation of Formulas—Graphic Method of Determining Angles—Values and Logarithms for Common Cases.

This volume is illustrated with numerous drawings which show the method of working for the various cases which are described, and a great deal of care has been exercised by the author in the preparation of these diagrams, which are clear and well drawn.

There is no doubt that the detailing of hip and valley rafters with the various connections is a matter that is likely to cause a great amount of trouble to the inexperienced draughtsman, and a volume devoted entirely to this section of constructional work should be of value. It is rather surprising to find that so much matter can be presented by such a limited subject, but there certainly do not appear to be any superfluous notes or drawings. The method of finding the necessary numerical values, both algebraically and graphically, is fully explained, and much of the calculation is simplified by means of tables. The book is well prepared, and although its use will obviously be limited, as the subject is not one which has to be dealt with every day, there is no doubt that it will meet the needs of the structural draughtsman when he is engaged in solving problems in hip and valley construction.

"Fire Tests with Roof Coverings of Asbestos Cement Corrugated Sheets Submitted for Test by the Asbestos Manufactures Co. Ltd."

Red Book No. 174 of the British Fire Prevention Committee. Published at the Offices of the Committee, 8 Waterloo Place, S W. Price 2/6.*

This Red book deals with tests undertaken with eight roofs covered with asbestos cement corrugated roofing, with pitches of 32°, 45°, and 68°.

In the case of roofs 1 to 4 the roofing was on boarding, for roofs 5 and 6 the roofing rested on purlins, and in roofs 7 and 8 the ends of the roofing were bedded on the wall.

The tests were of 30 minutes', 45 minutes' and 60 minutes' duration.

In some cases the removal of the fire was to be followed by the application of water, whereas in others no water was to be played upon the roof.

The progress of the various tests is given in the form of logs, and in each case the observations after test recorded. The report is excellently illustrated, and all dimensions are given, with metric equivalents.

*(A German edition of the Report has also been issued by the Committee's Continental Publishers (The Rechtsverlag, 6A Königstrasse, Hannover).

"Experiments with Fixed Beams" ("Versuche mit eingespannten Balken"). By Dr. F. E. von Emperger.

Leipzig and Vienna: Franz Deuticke. 1913. Price Mk 10.

The reinforced concrete committee of the Austrian Association of Engineers and Architects planned a series of experiments on the strength of beams fixed at both ends, which have been carried out by Dr. von Emperger, and are now described in his report. Some freely supported beams were included for purposes of comparison, as well as some balanced by a load beyond the bearing. The beams were prepared and tested at the Association's testing place at Heiligenstadt. The testing method employed was the simple one devised by Dr. von Emperger, and previously described in this journal. Delicate instruments of the Martens type were used for the measurement of deflections. In addition, as is usual in Continental work, each beam was photographed at the stage at which cracks became visible, and a complete record of the manner of fracture was obtained. The effect of the loading on the walls into which the beams were built was also observed and recorded.

The principal conclusions arrived at as the result of these very extensive tests are:—

1. Every beam which is not specially constructed as a freely supported beam should be regarded as at least partially fixed, and the reinforcement at the ends should be distributed accordingly. The

compression zone should never be entirely free from reinforcement.

2. In computation, the moment of flexure at the bearings must always be taken into account as well as the bending moment in the middle.

3. Where proper connection is made between the beam and its bearings, the beam may be regarded as completely fixed, and a moment of $\frac{ql^2}{12} = 0{\cdot}083\ ql^2$ may be assumed at the ends and one-half of that value in the middle. The bearing is to be regarded as including not only a section of the wall of the same breadth as the beam, but a wider section depending on the quality of the material in the wall.

4. In doubtful cases a less degree of fixing may be assumed. The experiments show that the distribution of stress adapts itself to the reinforcement.

5. The most complete fixing is obtained by completely connecting the reinforcement of the beam with the bearing, as in frame construction. In the absence of such a plan, the ends of the reinforcing rods may be merely bent over and embedded in the concrete of the bearing wall.

6. With sufficiently rigid connection, the beam and bearing wall may be computed as a statical whole.

7. Where the wall is of brickwork set in lime mortar, it is advisable to compute the beam as if freely supported, but to provide for partial fixing by bending up the reinforcing rods. A suitable support of Portland cement concrete may, however, be built into the wall.

8. The construction of corbels at the ends of the beams is of advantage. When these are large, the construction behaves as a cantilever, and the stresses are greatly diminished.

"Concrete Building Blocks" ("Der Beton-Baublock"). By Max Keller.
Berlin: Verlag der Tonindustrie Zeitung. 1913. Price Mk 3.

This little work deals, clearly and compactly, with the use of concrete blocks in building. The types of hollow block described are classified as American, Russian, Austrian, and German, and examples of the application of most of these are given. The variety of the constructions described is considerable, ranging from boundary walls and farm buildings to a large water-tower, which also serves the purpose of a view-tower. Concrete blocks have also found considerable application in Germany in the erection of buildings for military purposes on manœuvring grounds, in place of the usual corrugated iron structures. A detailed account of the methods of manufacture is given, and one chapter contains the plans and drawings for a detached house of satisfactory architectural appearance constructed with "Phœnix" hollow blocks. The lintels, sills, etc., are in artificial stone, and the roof of cement tiles. The cost of hollow blocks is computed to vary from 10 to 17 marks per cubic metre, an average value being 14 marks. This is assuming that only a single machine is used, requiring the services of two men. Details of tests are also given, and the book contains much useful information concerning this very useful and simple method of construction.

EDITORIAL MEMOS.

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CORRESPONDENCE.

Under this heading we invite correspondence.

REINFORCED CONCRETE FAILURES.

DEAR SIR,—In your editorial notes in a recent issue under the above heading you gave two warnings on the matter of failures in reinforced concrete work.

The first one, addressed to the builder or contractor, is undoubtedly one with which everybody will agree, and this warning is certainly useful in view of the fact that many specialists send out invitations to tender broadcast, and in many instances these invitations are received by builders who have had no previous experience of reinforced concrete. To add to this warning, I venture to suggest that it would not be out of place to suggest to these specialists that they should send with their inquiries to builders sufficiently detailed specifications and bills of quantities to enable the builders to realise the true value of the work.

I am sorry to say that many specialists avoid giving details to builders in the hope of being able to obtain a cheap price. It is obvious that, if a builder with insufficient information gives a price for which he afterwards finds he cannot carry out the work, the man is tempted to scamp the work.

Taking the case of a builder tendering for an important job and receiving from about half-a-dozen or more firms of specialists offers of schemes and bills of quantities, he will undoubtedly price every one of them and incorporate whichever is the cheapest in his tender, as he has no means of deciding for himself whether the cheapest one is really the best.

Personally, I think that the danger of failure through this practice is rather large.

As time goes on and the specialists multiply, it is open for everybody who likes to do so to call himself a specialist, and to invite tenders on this basis in the hope of securing a job on which he is paid by royalty, commission, or by selling the reinforcement.

This brings me to criticise the second warning which you issue, and which I venture to submit is unfair to those who combine designing and contracting.

What is practically suggested in this second warning is that if those firms who combine contracting with designing have not yet had failures they are likely to have them in the future.

I do not see at all why such firms are more likely to have failures than those who simply borrow schemes from independent specialists, and I would say, furthermore, that all failures that I can call to mind in this country have actually happened in cases where the specialist was not the contractor.

What has actually taken place in the last few years is that firms of contractors, feeling uneasy owing to the amount of competitive systems that there are, and feeling a certain amount of uncertainty as to the relative merits of these systems, have actually either retained the services of a competent practitioner or engaged his entire services to advise them and to control the reinforced concrete department.

It should be obvious to the writer of your editorial notes that a firm who undertakes the designing and the contracting together undertakes considerably more responsibility as compared with a firm who goes in for designing only. The specialist contractor cannot lay the fault on an outside designer, and the disputes as to whether the design is wrong or the contractor is at fault vanish altogether when the whole work is carried out by one firm. Moreover, contractors who go to the care and expense of organising departments of their own will naturally be firms who have large connections and important interests to protect, and have therefore every incentive to retain the services of or employ thoroughly capable experts to advise them.

A.R.I.B.A.

The Editor, Concrete and Constructional Engineering.

POPULAR USES.

Under this heading it is proposed from time to time to present particulars of the more popular uses to which concrete and reinforced concrete can be put, as, for instance, in the construction of houses, cottages and farm buildings. Previous articles will be found in our issues of December, 1912, and January and March of this year.—ED.

CONCRETE COTTAGES.

THE following are some notes and particulars regarding a concrete cottage erected on Messrs. Rowntree's estate, York, to the design of their architect, Mr. J. Swain, under whose supervision the work was also carried out.

The cottage is an experiment to attempt to solve the question of cheap well-built sanitary cottages for agricultural labourers. Mr. Swain writes as follows:

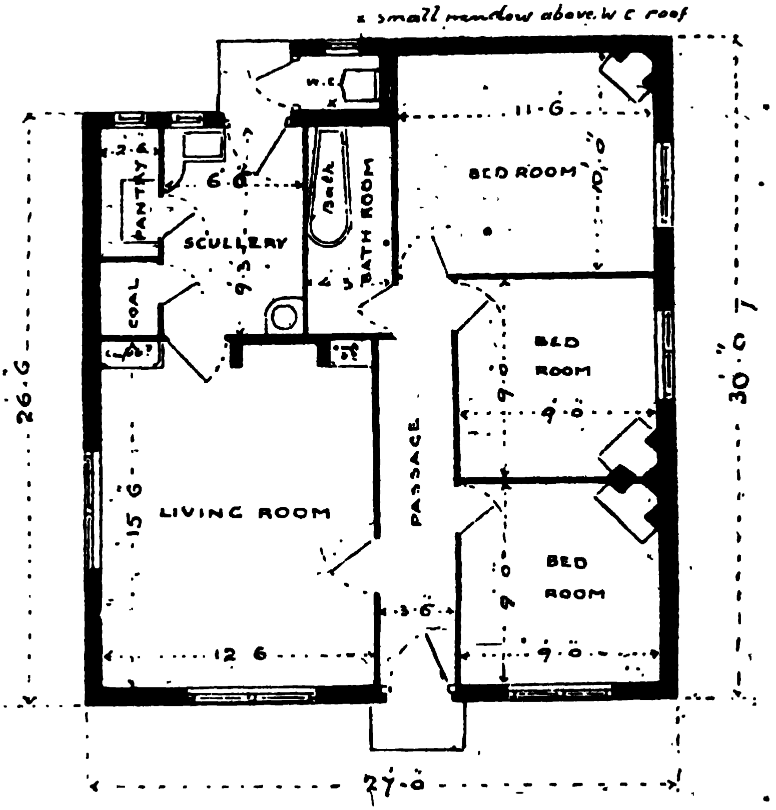
"Having designed very largely and erected numerous structures in reinforced concrete, I was convinced that if we would build cheaply and well, undoubtedly this is the

Concrete Cottage, York.
MESSRS. ROWNTREE'S ESTATE.

material to which architects will have to look for cheapness combined with durability. It must, of course, be borne in mind that concrete work must be well done, and exceptional care taken in the choice of materials and proportions, in order to have good results. The general architect is often inclined to look discouragingly on concrete because his experience has taught him that in all probability he will be troubled with expansion, cracks, and dampness, especially with regard to flat-roof construction. But practical experience has shown that with the proper selection of materials, and combined with Portland cement which will pass in every respect the British Standard Specification, there is little fear of these troubles arising. There are two great faults often made in connection with concrete work—namely, either too great a proportion of cement or too little is used. Each particle of aggregate should be thinly coated with cement grouting,

and the interstices filled with the smaller proportions of aggregate and not cemented together with lumps of pure cement as is often the case, otherwise there is sure to be difficulty with uneven expansion. Concrete for roofs should be composed of gravel or the like impervious stone."

The writer has found the most simple and satisfactory method of obtaining proper proportions of aggregate is to pass the gravel through a screen having a circular mesh of ¾-in. diameter, and grading the aggregate down from ¾ in. to pea size. This clean, wetted gravel should then be put into a bucket, filling it level with the top, and into this a sufficient quantity of water should be poured to fill up the interstices to overflowing. The proportion of water necessary to fill the bucket in bulk is the proportion of sand to be added to the gravel. Both sand and gravel must be well washed and free



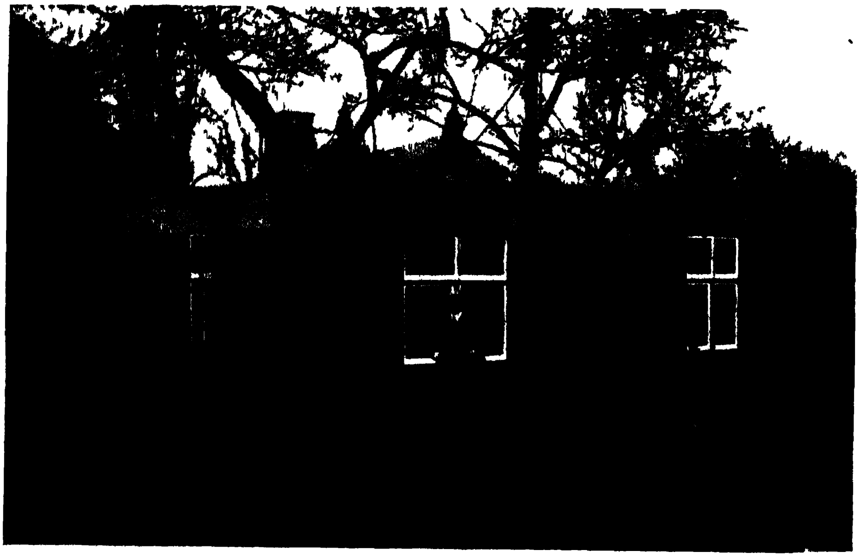
PLAN

CONCRETE COTTAGE, YORK.

from any foreign matter. Having obtained the proportions of sand required to mix with the gravel, the best proportion of cement is one to six in bulk. If these instructions are carried out, and the concrete thoroughly wetted in the mixing, and kept wet for a few days, there is little fear of leaky roofs. The usual cause of unsatisfactory concrete work has been due to the contractor taking very little heed of the concrete because he intends facing same with a granolithic finish. This must on no account be done if good, sound work is to be the result. The architect must insist upon the concrete being put down in a thoroughly wet mass, and, when it has sufficiently set to allow trowelling, the original surface must be well trowelled with a metal trowel. If concrete is allowed to set and is followed on with a rich mixture of granolithic topping,

a variation of expansion will be obtained, and expansion cracks will occur, and in many cases the granolithic will leave the body of the concrete.

The experimental cottage here described was constructed in every way to pass the local bye-laws of York. The external walls are 9 in. thick. There was, of course, no necessity to use such a thickness, as the writer has built a two-storey house at the seaside where the walls are only 4½ in. thick, but the bye-laws of York would not allow of any reduction. Blocks were cast in moulds, as shown in the accompanying photograph. The method of obtaining a rough cast finish was procured by putting a thin layer of sand at the bottom of the moulds, embedding into it some sharp, clean basic slag, and then about 4 in. of good solid gravel concrete. The mould was then filled up with concrete composed of clean, screened boiler ashes. The ash concrete was used for two purposes, firstly, because it was cheaper than the gravel, and secondly, because it forms a good surface for skimming over with plaster, and prevents condensation to the walls. The same course is adopted for the reinforced concrete flat roofs and is worthy of comment. When making the slab at least 1 in. of good ash concrete should be put down and covered over immediately with the gravel concrete. This gets over any



Concrete Cottage, York
MESSRS. ROWNTREE'S ESTATE

difficulty experienced with extreme variations of temperature The internal walls were made entirely of ash concrete 2½ in. thick, and a mould and sample block are also to be seen in the illustration.

The *modus operandi* for constructing a cottage adopted by the writer is as follows :—

Strip off the vegetable soil, and fill in with hard clinker ashes or broken stone or other suitable material, lay over the whole of the site a 4 in. concrete slab composed of good gravel concrete, bring up the sides the width of the walls to 6 in. above the existing earth line. This forms a raft similar to an inverted box lid. Care must be taken that the whole of the concrete necessary to form this slab and the sides shall be done in one day to prevent cracks or faulty adhesion. After a couple of days' setting the laying of the blocks forming the external walls can be proceeded with. These walls, which have a very rustic appearance from the outside, have been smoothed off when cast on the internal face, so as to dispense with expensive plastering. In a number of cottages it would be quite sufficient to give these walls a coating of lime-wash or

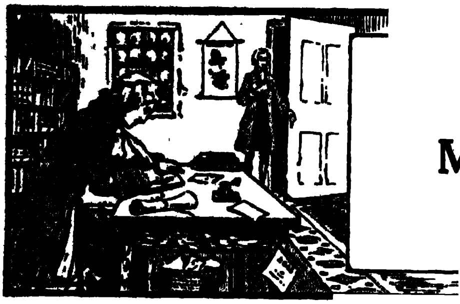
distemper, but in the cottage in question the walls were lightly skimmed with a coat of lime-putty gauged with plaster of Paris. The windows were built in as the work proceeded, and the fascia was formed of solid concrete. This was done in order to embody small pieces of steel to stretch the wires for the reinforced concrete roof. The floor boards come in useful for centering for the concrete roof.

The concrete roof was composed of gravel concrete carefully graded and mixed six to one. The wire reinforcement was then stretched across from side to side, and the slab cast 4 in. thick with stiffening beams on the outside so as to dispense with expensive wooden forms and also unsightly ceilings. This slab was trowelled after it was properly set, and has proved perfectly watertight.

Ash concrete was placed upon the gravel concrete floors to the necessary thickness, and the floor boards were nailed down to the same. When fastening the boards to the breeze or ash concrete foundation, care must be taken that the boards bed down solid on to the concrete. If the concrete is not perfectly level, fine ash should be sprinkled over in order that there shall be no air spaces between the boards and the concrete. The concrete must also be thoroughly dry before it is covered with boards. Unless these two items are carefully watched, trouble will arise from rot. The writer's experience, especially with large factory work, is that, provided the concrete is dry and the whole of the air expelled from under the boards, a thoroughly sound floor can be obtained. Immediately it is endeavoured to get a small air space by inserting strips as is often done, dry-rot will ensue, which spreads very quickly in vitiated air.

The chimneys were very carefully worked out to prevent down draughts, by providing adequate openings on each side, covered with concrete slab. It is often said that low shaft chimneys will not draw, but no difficulty has been experienced, although this cottage is placed in low land at the bottom of an orchard, and is surrounded by tall trees and higher buildings. The living room, which is 15 ft. 6 in. by 12 ft. 6 in. is provided with kitchen range, and the copper in scullery is built at back of the range with specially constructed flue and damper, so that the water in the copper is heated by the fire of the range. From the copper a pipe is fixed so that hot water can be discharged into the bath. In this case a w.c. was constructed as earth closets are not allowed, but the cost given does not include drainage.

In addition to the living room and scullery above mentioned, the cottage comprises a bathroom, one bedroom 11 ft. 6 in. by 10 ft., and two smaller bedrooms, each 9 ft. by 9 ft. There is also provision for coals, and a passage 15 ft. 6 in. by 3 ft. 6 in. The height of the rooms is 8 ft. 6 in. The cost of labour and materials was together £88 12s. 8d., but it should be stated that no charge has been made for the boiler ashes, which were supplied free, and for which 1s. per load cartage was paid. This cottage has been inspected by the Right Hon. Walter Runciman, who expressed great satisfaction with the accommodation and appearance.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

BUILDING TRADES EXHIBITION, OLYMPIA, APRIL 12th TO APRIL 26th.

WE have been unable to obtain an advanced copy of the catalogue of the Building Trades Exhibition, but we learn that amongst the many concrete exhibits and kindred trades, the following firms have obtained space, and will, as usual, be thoroughly represented :—

Art Metal Construction Co., Ltd., 5-11, Holborn, E.C.—Stand No. 104, Row E.

The Associated Portland Cement Manufacturers 1900) Ltd., Portland House, Lloyds Avenue, E.C., will have their usual stand, No. 120, Row F.

R. H. Baumgarten, 8, Manor Park, Lewisham, London, S.E., of First Cottbus Cement Goods and Machine Works.—Stand No. 128, Row F.

Bell's United Asbestos Co., Ltd., Southwark Street, S.E.—Stand No. 168, Row H.

Bispham Hall Colliery Co., Orrel, near Wigan. Stand No. 73, Row D.

British Ceresit Waterproofing Co., Ltd., 68, Victoria Street, S.W.—Stand No. 210, Row J.

The British Steel Piling Co., Dock House, Billiter Street, London, E.C.—Stand No. 7, Bay, in the Gallery.

The Expanded Metal Co., Ltd., York Mansion, York Street, Westminster, London, S.W., have their usual stand, No. 157, Row G.

General Fireproofing Co., 34-36, Gresham Street, E.C.—Stand No. 95, Row E.

Homan & Rodgers, 17, Gracechurch Street, E.C.—Stand No. 130, Row F.

Ironite Co., Ltd., 1, Victoria Street, S.W.—Stand No. 214, Row J.

W. Kennedy, 11, Furzeham Road, West Drayton, Middlesex.—Stand No. 45, Row C, where demonstrations of rod-bending machines can be seen.

Kerner, Greenwood & Co., King's Lynn.—Pudlo waterproofing.—Stand No. 33, Row C.

J. A. King & Co., 181, Queen Victoria Street, E.C.—Stand No. 112, Row F. Mack partitions.

Kleine Patent Fire-Resisting Flooring Syndicate, Ltd., 133, High Holborn, W.C.—Stand No. 119, Row F.

Lewis, Berger & Co., Homerton, N.—Stand No. 59, Row D.

F. McNeill & Co., Lambs Passage, Bunhill Row, E.C.—Stand No. 103, Row E.

Ozonair, Ltd., 96, Victoria Street, S.W.—Stand No. 176, Row H.

The Ransome-verMehr Machinery Co., Ltd., 508, Brunswick House, Westminster, London, S.W.—Stands Nos. 218-219, Row K, where exhibits of concrete mixing machines and steel piling will be on view.

Reinforced Metal, Ltd., of Glasgow, will have an exhibition demonstrating a new form of column construction which will call for considerable attention and create great interest in engineering circles.—Stand No. 136, Row F.

Ruberoid Co., Ltd., 81-3, Knightrider Street, E.C.—Stand No. 152, Row G.

G. R. Speaker & Co., 29, Mincing Lane, E.C.—Stand No. 63, Row D.

The Trussed Concrete Steel Co., Ltd., 60, Caxton House, Westminster, London, S.W.—Stand No. 154, Row G.

Vibrocel, Ltd., Eldon House, Eldon Street, E.C.—Stand No. 144, Row G.

Vulcanite, Ltd., 118, Cannon Street, E.C.—Stand No. 105, Row E.

The (U.K.) Winget Concrete Machine Co., Ltd., Newcastle-on-Tyne.—Stand No. 193, Row J. Continuous demonstrations will be held of the "Winget" concrete block and slab-making machine, the "Titan" concrete block and slab-making machine, and the "Express" hand-power mixer.

Most of the other well-known firms will be represented, and the exhibition bids fair to be as great a success this year as any held in the past.

Visits to the Exhibition.—By the courtesy of Mr. H. Greville Montgomery, the members of the ***Institution of Municipal Engineers*** will visit the Exhibition on Saturday, April 12th, at 3.30 p.m., the Exhibition authorities having kindly supplied cards of admission.

Similarly the members of the ***Concrete Institute*** will visit the Exhibition on Thursday afternoon, April 24th, at 3 p.m. Applications for tickets of admission should be made by members to the Secretary of the Institute.

The British Fire Prevention Committee's Testing Station.—Owing to the greater demands made upon the British Fire Prevention Committee for testing facilities, it has been decided to enlarge their testing station and to add to their plant.

The main building is also being rearranged in such a form that the principal rooms will be available for the committee's interesting technical and historical collections.

It is anticipated that the alterations will be completed early in April, when the testing operations for the new session will commence with several tests of fire-resisting doors, various forms of glazing, some new extinguishers, and certain further tests with concrete floors, etc., and with partitioning materials.

Apart from the usual appliances for fire tests emanating from Great Britain and the Colonies, there is a marked increase of requests for tests from Germany and from the United States, where the Committee's reports also enjoy the recognition of the public authorities.

ERRATUM.

Messrs. Newhouse's Premises, Middlesbrough.—We regret that the block (section) p. 204 of our March issue was inadvertently inserted upside down.

TRADE NOTICES.

The Dring Building Block Machine.—This machine consists of a substantially built mould box, the sides and ends of which are hinged to a fixed table, and when closed they are held in position by wedge-shaped standards. The machine is simple in action. It is claimed that either hollow or solid building blocks with any design of face can be quickly and effectively made on the Dring machine; further, that all classes of buildings can be quickly erected with its aid. Some buildings recently erected, viz., a pagoda at Wynward Park and St. Mary's Presbytery, Stockton-on-Tees, were illustrated and described in our February issue.

Other buildings erected include a church at Horden, Durham.

It is claimed that two men can make some 275 to 300 blocks per day, working nine hours per day, on one of these machines.

Illustrated booklets and full particulars can be obtained from Messrs. J. Wilson Browne and Son, Ltd., 32-35, Ludgate Hill, Birmingham, who are the sole selling agents and licensees.

Reinforced Concrete Reservoir (Piketty System).—The Rural District Council of Sedgefield, Durham, has accepted the tender of Mr. J. W. White, of Sunderland, for the construction of the new water reservoir, in accordance with the plans of Messrs. Paul Piketty and Co., Reinforced Concrete Engineers, London, W.C.

CONTRACTS.

Large Cement Contracts.—We understand that the Associated Portland Cement Manufacturers (1900), Limited, have recently completed contracts for approximately 300,000 tons of Portland cement with eminent English and French contractors for use in important port works at Buenos Ayres and Mar del Plata in the Argentine, and at Rio de Janeiro.

UNIVERSAL JOIST . .
STEEL SHEET PILING

Illustration shows cross dam at the Entrance to Chertsey Lock which is now being reconstructed by the Thames Conservancy. It is a single row of our 15 inch × 43 lb. Piling, and is quite watertight. The same kind of piling is also being used for retaining the sides of the Lock, afterwards being covered with concrete and forming part of the permanent work.

THE STRONGEST PILING ON THE MARKET.

Telephones: [illegible] Avenue. [illegible] Central.
Telegrams: "[illegible]" London.

The British Steel Piling Co.

Dock House, Billiter Street, LONDON, E.C.

The Wouldham Cement Co., Ltd., have also, we understand, contracted with Messrs. S. Pearson and Son, Ltd., for about 140,000 tons of Portland cement, required for the new Royal Albert Dock, London, and for the new port works at Valparaiso, Chili.

CATALOGUES RECEIVED.

The Spiral Bond Bar Co. Ltd.—A new catalogue recently issued by this company has been sent us. The booklet sets forth the advantages of the "Trisec" spiral bond bars for reinforced concrete construction.

The bars are produced by two mechanical processes: first of all, straight bars of special section are rolled, and then the bars are gently and gradually treated until they attain a spiral form. Powerful machinery is used for the mechanical process, and the operation is so carried out as to avoid injury to the structure of the metal.

It is claimed that the spiral form of the bar provides a perfect mechanical bond, which is capable of effective resistance to tensile or compressive stress, as required.

Briefly, the principal advantages claimed are: (1) economy and efficiency; (2) the mechanical bond saves the cost of mechanical preparations; (3) higher stresses can be employed; (4) high buckling resistance in the case of compression members; (5) reduced weight, thus saving freight and cartage, etc.

The booklet contains many illustrations of buildings where the bars have been employed, which include warehouses, grain silos, water-towers, lodging-houses, etc., etc. Illustrations of the works where the bars are manufactured are also given.

Full particulars can be obtained from the company at their offices, Caxton House, Westminster, S.W.

The British Steel Bar Co. Ltd.—We have received a catalogue dealing with the company's "Helyxa" bar. The booklet briefly explains how these bars, twisted in shape, are made, and the various advantages attached to their use are set out.

It is claimed that these bars have a highly efficient mechanical bond; owing to the continuity of the rib running spirally round the bar it carries its full share of stress in the structure, *i.e.*, the whole of the steel in the bar carries stress; no fishtailing is required; increased bending resistance is obtained in comparison with the resistance obtained from plain and untwisted bars; a saving is effected in the steel; lastly, it is stated such bars are free from flaws owing to the mechanical process employed in manufacture, and they have absolute surface contact with the cement. Some tests made with the bars are reported on.

Full particulars can be obtained on application to the company at their offices, 17, Victoria Street, Westminster, S.W.

ENQUIRY.

DEAR SIR,—I shall be very glad to know if any of your correspondents can inform me if it is feasible to construct a reinforced concrete tank which will be able to hold pure, clean water practically at boiling point? The tank is to be 15 ft. square and 10 ft. high.

I shall be glad if you could give me any information on this subject.

I am, yours faithfully,

The Editor, Concrete and Constructional Engineering. ENQUIRER.

Replies.

1st Reply.—I have had no experience of the effect of boiling water on concrete, but I do not imagine that there would be any direct trouble experienced with disintegration of the concrete, as one of the tests for the soundness of cement is for the briquette to be immersed in boiling water.

With such a small tank, 15 ft. square by 10 ft. high, I see no difficulty in making it of reinforced concrete, provided the base and sides of the tank are not restrained by outside forces, so that contraction and expansion could be taken up without inducing stresses on the structure. If, on the other hand, the bottom and sides of the tank are restrained in any way, the temperature stresses could be taken up quite well by adequate reinforcement. C. P.

2nd Reply.—With reference to inquiry concerning reinforced concrete tank to hold pure, clean water practically at boiling point, I consider that it is quite feasible to construct this, although I do not know of any example in practice of a similar nature.

Concrete should not be affected or damaged by boiling water if the cement is of the right quality and proper precautions are taken in the execution of the work. I should suggest that the reinforcement be in the form of several small bars in both directions in preference to a comparatively few bars widely spaced. The work should also be allowed to stand for the maximum period of time after execution before being put into use. The concrete should be a rich mixture, and the best aggregate would be a clean ballast. A. L.

3rd Reply.—I have not had any experience of concrete being subjected to the conditions mentioned in the above inquiry, but from experience with high dry temperatures, providing the concrete was properly made and properly reinforced, a dry heat of 212° F. should not affect it, but after some period it is possible the concrete may commence to disintegrate with a wet temperature of 212° F. It is presumed that the tank would be open or that the steam would have free exit. I think, however, the principal trouble would be found at the water-line, where the concrete below and above the water would be subjected to such entirely different conditions. A. H. S.

Photographer] THE MIDDLESEX GUILDHALL *(For description see page 299.)* [*E Milner, Wandsworth, S.W*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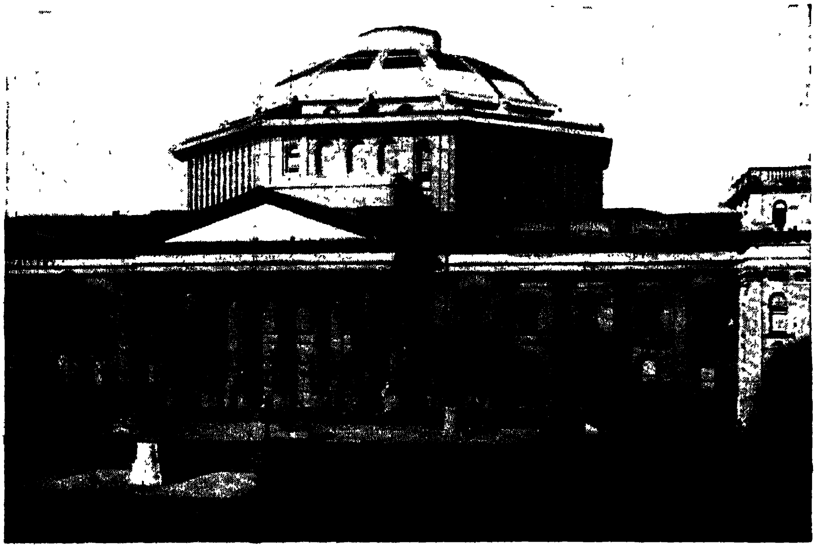
May. 1913.

A CHEF D'OEUVRE OF REINFORCED CONCRETE ON THE KAHN SYSTEM

THE TRUSSED CONCRETE STEEL CO., Ltd.



The Dome of the Melbourne Public Library. *Messrs. Bates, Peebles & Smart, Architects*

THE LARGEST REINFORCED CONCRETE DOME IN THE WORLD. CONSTRUCTED ON THE KAHN SYSTEM

Apart from steel-constructed domes, this dome is only surpassed in span by that of the Pantheon, which is 142 ft., and of St. Peter's, Rome, which is 137 ft. The Melbourne dome illustrated above covers an octagon, and the span between opposing inside faces of tension band is 124 ft. 6 in., St. Sophia at Constantinople being 105 ft., and St. Paul's 102 ft. The Melbourne dome is, however, the largest Reinforced Concrete dome, and was carried out to the designs of the Trussed Concrete Steel Co., Ltd., of Caxton House, Westminster, who were the Consulting Engineers for this part of the work, with Kahn System Reinforcement. The top of the lantern is 114 ft. above the level of the reading-room floor.

THE TRUSSED CONCRETE STEEL CO., Ltd. 60 CAXTON HOUSE, WESTMINSTER, S.W.

N.B.—The Trussed Concrete Steel Co., Ltd., will be glad to collaborate with Engineers on any constructions, and place at their disposal the skill and experience of their Engineering Staff.

Please mention this Journal when writing.

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume VIII. No. 5. LONDON, MAY, 1913.

EDITORIAL NOTES.

BUILDING TRADES EXHIBITION.

FOR all interested in building construction and structural engineering, the event of last month has certainly been the great Building Trades Exhibition at Olympia, which has been eminently interesting and again indicated what forethought, careful organisation, and a definite purpose can achieve in exhibition management.

In one or two directions, however, we should like to make some suggestions. First of all, having regard to the dearth of new inventions or so-called novelties in the Exhibition, it might be advisable to hold the Exhibition only once in three years or every four years. We believe that many of the exhibitors would be quite prepared to even pay a higher rate for their space if a somewhat longer interval intervened, and both the visitors and the exhibitors would probably appreciate the change, which need not mean any great pecuniary loss to the Exhibition management if the space rates are proportionately raised.

Secondly, we think the management should rather discourage large paint exhibits, which, however handsome in themselves and at this particular Exhibition quite exceptionally beautiful in certain cases, are in reality rather monotonous and uninteresting; and as the management is in that excellent position of being able to pick and choose its exhibitors, it might be better to allot more space to the really interesting exhibits and give these displays of paint work a lesser superficial area.

Thirdly, regarding the general characteristics of the Exhibition, we fully realise the difficulty of enforcing regulations as to the character of the Exhibition stands, and the absence of onerous regulations *cum* competition has certainly led to a vast improvement in the stalls; but we certainly think there should be a limit of height both as to minimum and maximum. There was one very handsome exhibit housed in a half-timber house near the main entrance that largely spoilt the vista of the whole; and, on the other hand, there were certain exhibits on island sites which were not sufficiently pretentious and rather spoilt some of the principal points, to which more prominence should have been given.

Another suggestion that would make for more prolonged visits by the older and perhaps more influential visitors, on whose specification the exhibitors largely depend, is the provision of ample chairs and seating accommodation on the main floor of the building. There was some attempt at this in the annexe,

but it should be remembered that many of the class of visitors who are really useful to the Exhibition have a distaste for sitting in tea or refreshment rooms and yet find a prolonged visit to the Exhibition too tiring without the facility for rest at intervals. Exhibitors themselves would also do well to have a more ample provision of chairs on their stalls if they wish to explain their systems and specialities at leisure to some of the older members of professions primarily concerned.

As far as the purely structural exhibits are concerned—*i.e.*, steel frame construction, concrete and fire-resisting construction, other than brickwork—we were somewhat disappointed at the rather limited number of exhibits in this particular section, and we all too fully realised that the concrete or reinforced industry had not made proper use of the very excellent opportunity afforded it, which we think to the detriment of its advancement. We have inquired very carefully into the reasons for this, and have come to the conclusion that this is partly due to the difficulty of obtaining suitable space for substantial displays, and, above all, to the limited time available for the preparation of exhibits of a structural character; and we thus venture to suggest whether the time has not arrived for arranging for outdoor exhibits, for which suitable space could be devised under temporary shelters both in front of the main façade and at the side.

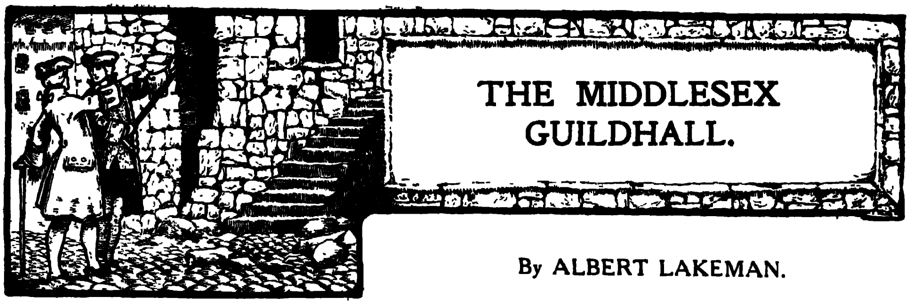
We trust this matter may have the careful consideration of those interested in the subject, for we believe it would be eminently beneficial to those industries in which this journal is primarily interested if outdoor exhibits could be arranged for.

With the Exhibition itself we deal in a special article, and in conclusion we would again congratulate the principal organiser thereof, Mr. H. G. Montgomery, J.P., for the really model lines on which the work is organised and conducted.

THE IMPENDING INTERNATIONAL ROAD CONGRESS.

We should like to take this opportunity of reminding our readers of the International Road Congress which is to take place in London in June (June 23rd to 28th), inasmuch as the problem of utilising concrete and reinforced concrete in road construction is a matter which is coming largely to the front and is finding experienced advocates both in the United States and on the Continent of Europe.

We have the unfortunate name at present in this country of lagging behind in matters relating to the careful consideration of the uses of concrete and reinforced concrete, and it might be well if, for once, an exception were made by us in taking the lead in the matter of investigation and research as to the use of concrete in road construction, seeing that there is no country where roads could be more economically and practically constructed of concrete than in England, and that this type of road is particularly suitable for our increasing commercial motor traffic.



THE MIDDLESEX GUILDHALL.

By ALBERT LAKEMAN.

The building here described is mainly of steel, and reinforced concrete only plays a minor part in the work, but there are many features of particular interest in the construction.—ED.

THIS important building has been erected from the designs of Messrs. J. S. Gibson, Skipwith & Gordon, on the site of the old Guildhall, close to Westminster Abbey, and it has an area of about 17,150 sq. ft., with a frontage of 102 ft. to Broad Sanctuary, facing the Abbey, and 160 ft. to Little George Street; while practically all the offices are lighted from the adjoining streets, as the site is an island one. The southern portion of the site has been covered for

Fig 1. View showing Steel Construction.
THE MIDDLESEX GUILDHALL.

several centuries by buildings devoted to the administration of justice, and in the new building it was absolutely essential to provide accommodation for the work of the Quarter Sessions of Middlesex, in addition to the chambers and offices necessary for carrying on the business of the Middlesex County Council, and the fact obviously governed the planning and design. The old Courts of Justice, which were demolished for the execution of the new building, were built towards the end of the eighteenth century, and the offices for the Middlesex

County Council were erected about seventeen years ago, but the reconstruction of the whole of the building was necessary owing to the large increase in the

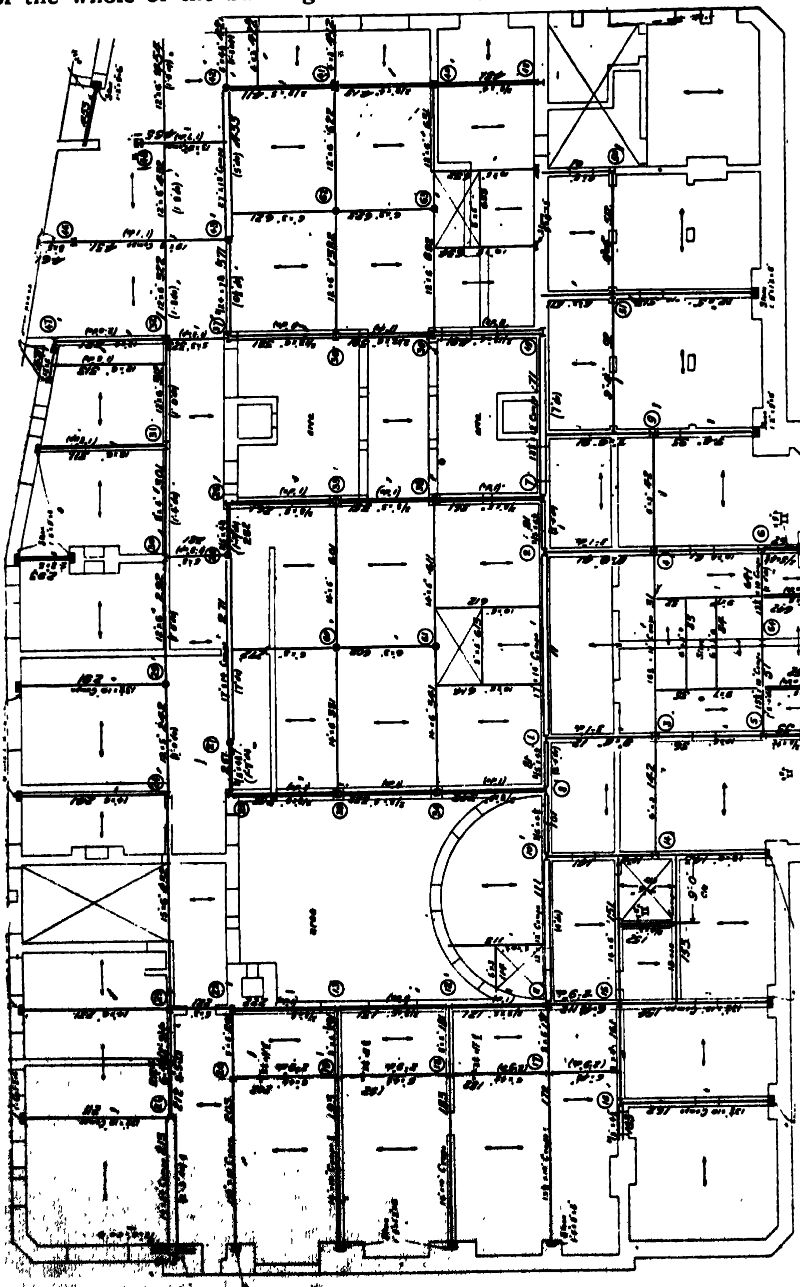


Fig. 2. Framing Plan at Ground Floor Level.
THE MIDDLESEX GUILDHALL

staff and the work of the officials, consequently the present scheme was decided upon in 1910.

An interesting discovery was made during the excavations by the contrac-

tors, who exposed a heavy rubble concrete raft, which appears to have been the foundation of the isolated belfry of the Abbey, erected about 1249-1253 and destroyed about 1760. This old belfry took the form of a stone tower, which was 60 ft. high, and finished with a leaded spire. The raft was about 80 ft. by 70 ft. in area and 5 ft. thick, and, curious to relate, was carried on elm and beech piles closely spaced and about 10 ft. long, although the soil below the raft was a very good ballast.

The new building is five storeys in height, giving a dimension of 50 ft. from the pavement level to the top of the main external walls, while the top of the parapet of the tower is 108 ft. above the same level. A basement floor is constructed below the pavement, and the greater part of this is allocated to the Prison Department, there being about 100 cells with accommodation for warders and wardresses and police, and also several witness rooms. The remainder of the floor is occupied by the heating and ventilation chambers, and the numerous record rooms, which are brick-vaulted and constructed with due regard to the safe storage of the valuable records belonging to the County Council.

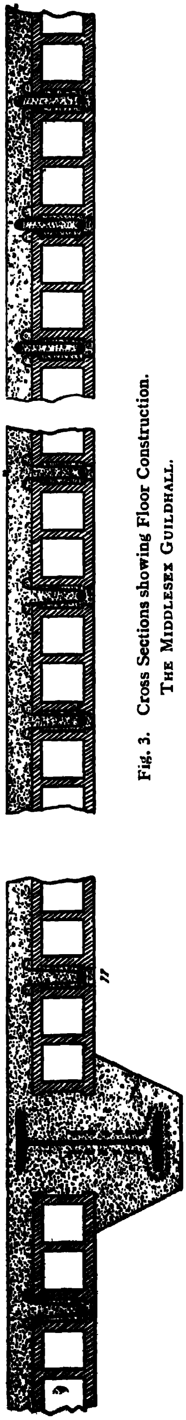


Fig. 3. Cross Sections showing Floor Construction.
The Middlesex Guildhall.

The ground floor is utilised for the courts, of which there is a large one situated in the centre of the building, entered directly from the large vestibule and lighted from two internal areas; and a smaller one situated at the north end of the building; both these courts extending through the height of two floors. In addition to these courts there are offices and private rooms for members. The first floor is devoted to committee and private rooms, and on the second floor the council chamber is planned to come over the larger court mentioned on the ground floor, and this council chamber provides accommodation for about 110 members and officials. A large ante-room is situated on the east side of the council chamber, and the remainder of the floor and also the third floor is given up to offices. The whole of the elevations are in Portland stone, and they have been designed in the Gothic style, which is in harmony with the environment of the building. The composition and detail of the building is very successful, and the tower—which is an important feature in the design—is happily proportioned, and adds additional interest to the scheme.

The construction of the building is executed generally with steel weight-carrying members, with floor panels of tile and reinforced concrete; while the foundation to the tower is formed with a reinforced concrete raft, 3 ft. thick, designed by the Trussed Concrete Steel Co., on the Kahn system This raft carries the six stanchions which support the tower, the load from which, including floor loads, amounts to about

1,800 tons, and this was distributed over sufficient area to give a pressure on the soil not exceeding two tons per foot super. The reinforcement generally consisted of 1-in. Rib bars.

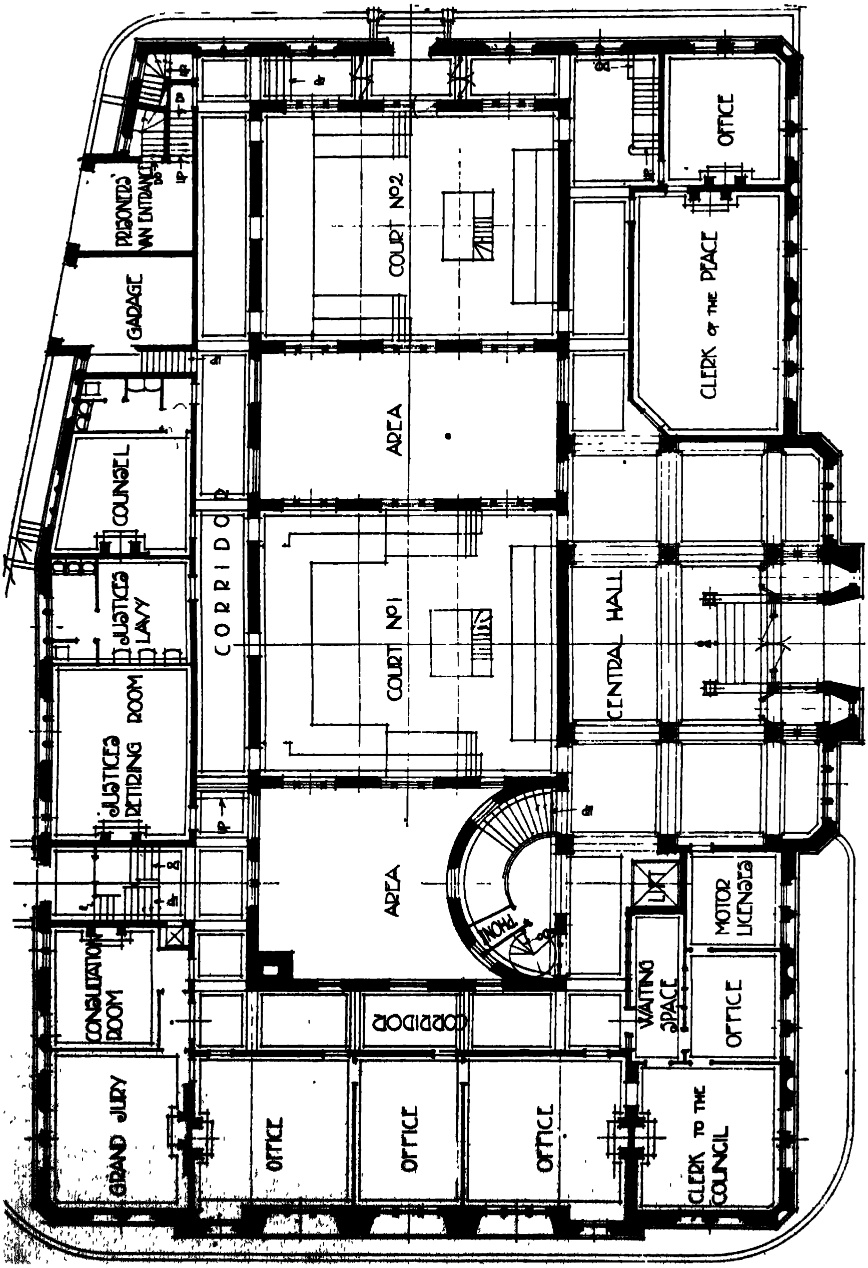


Fig 4. Ground Fl
THE MIDDLESEX G

A typical framing plan is illustrated in *Fig.* 2, which shows the steelwork at the ground-floor level. Generally speaking, the ends of the main beams are

carried by piers where they come against the external walls, and stanchions and columns are only employed in the interior of the building. A large number of compound girders were used, and these were built up with rolled steel joists and

Fig. 5. View showing Floor in Course of Construction.

Fig 6. View showing Completed Floor.
THE MIDDLESEX GUILDHALL.

plates, to give as shallow a section as possible. There were no exceptional spans or loads, owing to the straightforward plan, the longest span on the

drawing illustrated being about 24 ft., and the largest compound girder 27 in. by 18 in. over all. In the interior of the building columns and stanchions were used, and the latter are of the compound type, built up with rolled steel sections and plates, these in some cases resting on small grillage foundations, which were carried by the reinforced concrete raft.

The floor panels are constructed on the patent "Bigspan" system by Messrs. Diespeker, and these are calculated to carry a superimposed load of

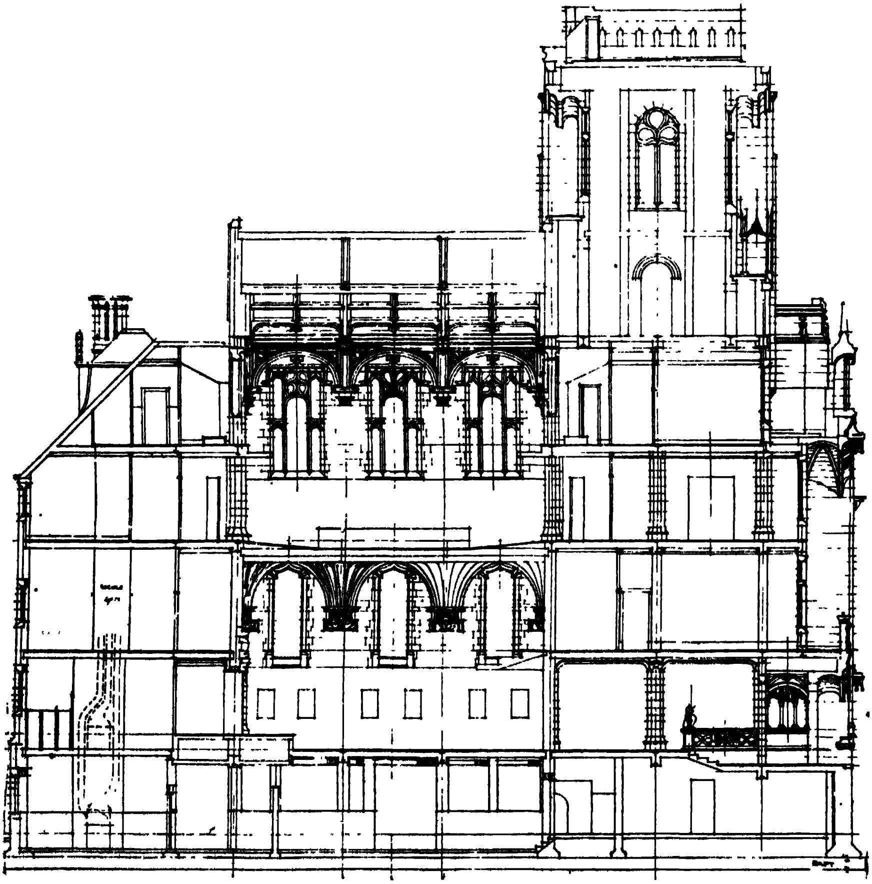
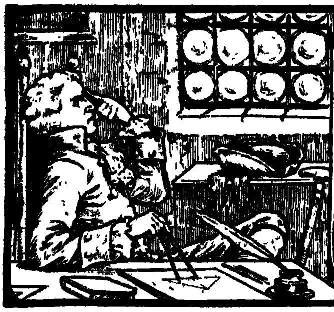


Fig. 7. Section.
THE MIDDLESEX GUILDHALL.

1½ cwt. per sq. ft. A section showing this type of floor is given in the illustration in *Fig.* 3, and it will be seen that hollow tiles are used, these being about 10 in. wide and 6 in. deep. These tiles are temporarily supported on planks during the construction of the floor, and the sides of same form the centering for the small reinforced beams, which are about 2 in. wide, with one rod on the lower surface in the centre of the span, and in addition one bar on the upper

surface to provide continuity where adjacent to the main steel beams. The bars are kept in position during concreting by the steel clips which pass round the reinforcement and are bent down at the top ends to rest on the tiles, as shown, these also giving provision against shear. About $2\frac{1}{2}$ in. of concrete is placed on top of the tiles, giving a total thickness to the floor of $8\frac{1}{2}$ in. The photographic views show the floor construction during progress, and some of the bays have a width of 16 ft., thus showing the possibilities of this system, which is light and eminently fire-resisting. The roof construction is executed generally with a shaped frame, built up with rolled steel joists, which can hardly be designated as an ordinary roof truss; but the roof over the Council Chamber is carried by two steel trusses, which have a span of 37 ft. 6 in., and these support 5-in. by 3-in. rolled steel purlins at 3-ft. centres. These purlins carry the concrete slabs, which in turn are covered with slating. The trusses have a principal rafter formed of two 6-in. by $3\frac{1}{2}$-in. by $\frac{1}{2}$-in. angles, while the ties and struts are formed with two $2\frac{1}{2}$-in. by $2\frac{1}{2}$-in. by $\frac{3}{8}$-in. angles. The ties have a rise of 6 ft. 3 in. at the centre of the span, and these are built up with two 6-in. by 3-in. by $\frac{1}{2}$-in. angles. The adoption of the method mentioned for the roofs generally allowed practically the whole of the space within the sloping portions to be utilised for rooms, which would not have been possible with ordinary roof trusses.

The building is heated on the vacuum steam system, and the courts, council chamber, committee and ante-rooms are ventilated and heated on a Plenum system. There are two drainage systems, the rain water being dealt with at the basement ceiling level and carried directly to the sewer; while the soil and waste water drains are carried to a pneumatic ejector which raises the drainage from the low level to a sufficient height to discharge it into the sewer. The general contractor for the work was Mr. James Carmichael, and the steelwork was executed by Messrs. Redpath, Brown & Co. The floors were carried out by Messrs. Diespeker, and the reinforced concrete raft by the Trussed Concrete Steel Co.



REINFORCED CONCRETE BEAMS.

ON THE RESISTANCE OF BEAMS SUBJECTED TO FLEXURE.

(1) SOLID RECTANGULAR BEAMS—SUPPORTED ENDS FREE.

By ALFRED FYSON, M.Inst.C.E.

The following is the first of three articles prepared by the Author, on the above subject, and should claim the attention of all interested.—ED.

Introduction.

THE method employed for determining the moment of resistance of a reinforced concrete beam which now finds most favour with writers on the subject, and one also which appears to be most generally practised in constructional work, is the simple one of supposing all internal longitudinal tension to be resisted by the reinforcement, the value of the concrete for such stress being ignored. One of the reasons for thus neglecting the tensional value of the concrete is the striving after so-called " simplicity "; another reason is due to the little knowledge possessed as to its behaviour at comparatively small strains, and a total lack of knowledge as to its behaviour at great strains.

The fact that an important element of a beam is thus theoretically eliminated whilst it is of necessity physically retained, precludes any possibility of rational or scientific treatment, as the premises on which such treatment is to be based must be more or less false.

Instead of there being produced some rational theory founded on exact principles for determining the value of the moment of resistance, there are substituted certain assumed conditions which are made to serve as bases for the arithmetical computation for such purpose.

Some of those assumed conditions are as follows :—

" The modulus of elasticity is supposed to be constant for both compression and tension in the same material; consequently the stress is directly proportional to the strain."

" The value of the tensional resistance of concrete being considered comparatively small, all such resistance is supposed to be taken up by the reinforcement; consequently the position of the neutral axis must be determined solely by the value of the concrete in compression and that of the reinforcement in tension."

" The theory of ' the conservation of plane surfaces ' is to be observed; consequently all internal strain is uniformly varying."

Now, with the exception of the last condition—and with respect to that it must not be inferred that all internal stress is uniformly varying—the others as set forth and their corollaries are not strictly true for small stresses and strains, and are not even approximately true for maxima limits usually adopted in practice. But it is claimed for such and similar conditions arising from them, that whatever departure from accuracy they may occasion or whatever failings they may possess separately or combined, errors due to such causes will be in the nature of excess of strength beyond that demanded.

With a view to test the validity of such claim, the following investigations have been undertaken. The laws which govern the theory of elasticity and flexure as generally accepted for homogeneous materials will form the basis for rigorous mathematical

treatment. Equations will be deduced for the method which *excludes* the value of the concrete in tension; other equations will be proposed for the method which *includes* the value of the concrete in tension. A beam of some definite dimensions will be calculated by both methods, and the resulting numerical details will furnish practical means for comparing them.

In order to distinguish herein between these two diverse methods, that which *excludes* the value of the concrete in tension will be termed a theory of "Partial exclusion," and that which *includes* the value of that material in tension will be termed a theory of "Complete inclusion"; the terms "exclusion" and "inclusion" having reference to the horizontal components of the internal resisting forces. The principal explanatory data and symbols to be employed are as follows:—

All linear dimensions are in inches.

All loads in lbs., and stresses in lbs. per sq. inch.

All strains are in fractions of one inch, or proportion of the length involved.

Generally the subfix $_o$ designates the symbol as affected by compression.

B, H = respectively the breadth and depth overall of a beam.

D = depth from compression surface of beam to the axis of reinforcement.

V = effective depth of concrete, *i.e.*, its unruptured depth.

F_o, F'_o = some desired or permissible unit stress on the concrete in compression.

F = unit stress in tension on the concrete at its extreme outer surface.

F'_s, f_s = some permissible or deduced unit stress on the reinforcement.

E'_c, E_c = some specified or actual modulus of elasticity for concrete in compression.

E_s = the modulus of elasticity of the metal constituting the reinforcement.

$d_o\ v_o\ h_o$ = positions of the neutral axis of a beam with respect to the extreme outer compression surface.

d, v, h = positions of the neutral axis of a beam with respect to the axis of reinforcement.

$M'_R\ M_R\ \mu_R$ = moments of resistance of a section as allocated herein.

a_s = the sectional area of the reinforcement.

$\sigma_r\ \sigma'_r$ = the "elastic" strain for compression on the concrete due respectively to F_o and F'_o.

$\lambda_r\ \lambda'_r$ = the "elastic" strain for tension on the concrete at its exterior surface.

$\eta\ \eta'$ = ,, ,, ,, ,, tension on the metal constituting the reinforcement.

Other symbols, etc., will be found duly set forth as occasion may demand them. With respect to the symbols d, d_o; v, v_o; h, h_o; those under d refer to beams in which the tension on the concrete is entirely neglected; those under v refer to beams in which the concrete is capable of resisting, and is supposed to resist, tension over some particular depth as defined by V; those under h refer to beams in which the concrete remains sound and unimpaired between the extreme upper and lower surfaces of a beam, the depth over all of the concrete thus becoming available for purposes of internal resistance.

By the term "strain," which will be frequently used in these investigations, is to be understood the longitudinal alteration of length due to force acting in the same direction; and by "stress" is meant the intensity of the internal resistance offered to such force.

The Theory of Resistance to Flexure

The generally accepted hypothesis respecting the theory of the internal resistance of a beam at a section as due to flexure may be briefly considered in the following manner:—

Let *Fig.* 1 represent part of the side of a rectangular beam of uniform section,

loaded in such manner that it is bent downwards, so that a constant bending moment exists throughout its length; thus only the action of the horizontal stresses and their corresponding strains will have to be considered. Let the moment of resistance of all the internal forces at the section $a\ a_0$ on the vertical line $Y\ Y_0$ be required. Assume an elementary strip bounded by the planes $Y\ Y_0$ *and* $Z\ Z_0$, its depth and breadth being of the same dimensions as for the beam, and its length unity, or, say, 1 inch.

Flexure causes the top of the beam to become compressed and the bottom to become extended, therefore the elementary strip is shortened some amount σ_T at one extremity and lengthened an amount λ_T at the other extremity of its depth.

Join the two points b_0 and b, so found by the straight line $b_0\ b$ representing the side of a plane surface through the beam. The original section $a\ a_0$ on the line $Y\ Y_0$ has gone through an angular movement and has shifted to the position $b_0\ b$, the only point which has not moved being at O, where the two sections cut each other; this point

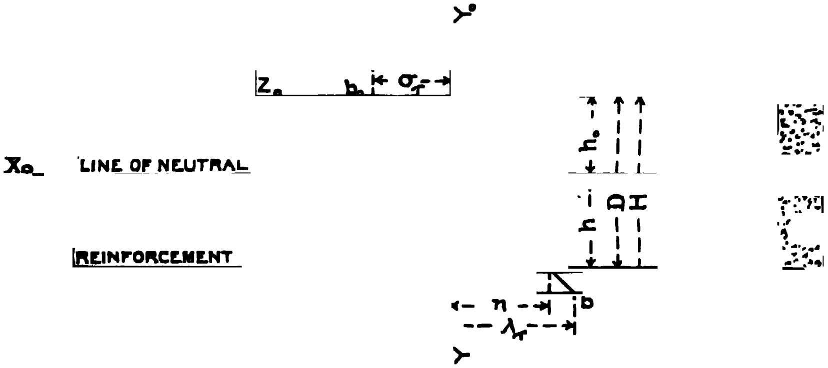


FIG. 1

O is at the neutral axis of the section $a\ a_0$. It will be noticed that the inclined line $b_0\ b$ has, by construction, been made a straight line; this is in conformity with what is termed "The theory of the conservation of plane sections," the meaning being that an originally plane section before bending remains plane during and after bending. Such a theory, however, can only be supposed to apply to materials which are perfectly elastic or in which the "set" has been eliminated or is so small that it need not be considered, and in such sense only will it be accepted in these investigations.

The actual longitudinal strains now imposed on the elementary strips between $Y\ Y_0$ and $Z\ Z_0$ are indicated by the ordinates of the two triangles the perpendiculars of which are represented by the lengths σ_T and λ_T. Corresponding with these strains are their stresses or internal resisting forces, and these—including the "tension" resistance of the reinforcement due to the extension η—do not vary in the same manner as the strains, but only in accordance with the relation between stress and strain for the particular materials employed, and that relation is never in direct proportion for any elastic substance. Within certain low but varying limits, however, the relation between stress and strain is generally assumed to be in nearly direct proportion for most materials of construction, and such proportion is generally known as Hooke's law. In order to define the exact position of the point O in the line $Y\ Y_0$ a condition of internal static equilibrium must be observed. Supposing the internal resisting forces or stresses of compression and tension to be represented algebraically as of opposite signs, that condition is expressed thus: the sum of the stresses must equal nothing. This, according to Fig. 1 means that the stresses of compression and tension due to the strains of shortenings and lengthenings in the two triangles bounded by the planes $a\ a_0$ and $b\ b_0$ must be equal to or balance each other.

From the point O draw in opposite directions the straight lines OX, OX_0, each normal to the line $Y\,Y_0$: the line X_0OX becomes a side of the plane of the neutral axis of the beam, its depth from the top of beam being designated by the symbol h_0.

The moment of resistance at the section $a\ a_0$ is found by adding together the products of all the internal normal forces and the distances of their respective centres of resistance from the neutral axis at O.

Mathematical Determination of the Moment of Resistance.

In the diagram *Fig.* 2 let X_0OX be the axis of strains, and YOY_0 that of stresses, and suppose $Ob_0'' b_0''$ to be a compression stress-strain curve for the concrete composing the beam. The part of the diagram above the axis X_0OX is to be allotted to compression and that below it to tension. In the first instance the concrete will be considered separately without reference to the reinforcement, and in all cases of strain it is to be understood that " elastic " strain is meant unless the " set " is specifically mentioned.

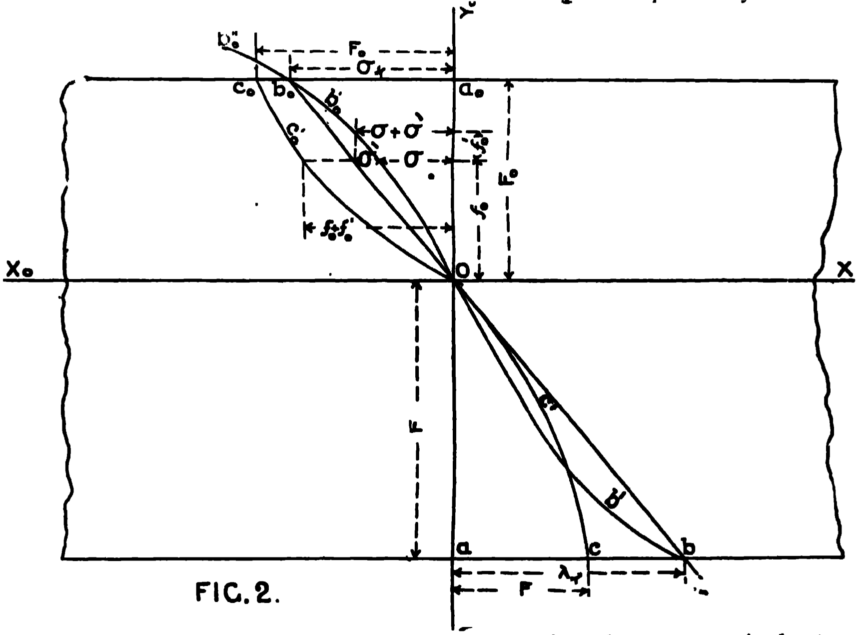


FIG. 2.

Let σ_r be the measure of strain or the shortening of an elementary strip due to some particular or desired stress F_0 in compression. Let the distance a_0b_0 as an ordinate to the curve $Ob_0'b_0''$, denote σ_r; through a_0 and b_0 draw a line parallel to X_0OX and prolong it in each direction. That line may be assumed to represent the top of the beam shown in *Fig. 1*, and the distance Oa_0 may be assumed to represent its depth for the part in compression. From the point b_0 draw a straight line through O and prolong it into the part of the diagram allotted to tension to some point b. The straight line b_0Ob is supposed to illustrate the "Theory of the Conservation of Plane Sections." Through b draw a line parallel to X_0OX, cutting the axis YOY_0 in the point a; that line, prolonged in each direction, may be assumed to represent the bottom of the beam *Fig 1*, and the distance Oa the depth of the part in tension. The measure of strain or the extension ab of the elementary strip is denoted by λ_r, which is a known or measurable quantity. With Oa as axis of stresses, construct the tension stress-strain curve $Ob'b$ for the concrete composing the beam, so that it passes through the point b already given, the point O being the origin. The ordinates to the stress-strain curves $Ob'b$ and $Ob_0'b_0$ must be drawn to the same scale, but owing to the fact that the two

curves are never exactly alike for the same material, the scales for the tension and compression stresses on the axis YOY_0 cannot be the same, but it is not necessary to consider here their relative proportions, as the diagram is only intended for practical illustration.

The effect of Flexure is to cause alterations of form in the stress-strain curves; thus the curve Ob'_0b_0 moves up to and coincides with the straight line Ob_0, and the curve $Ob'b$ moves up to and coincides with the straight line Ob: the curves of strains now become straight lines, and their corresponding stresses can be graphically represented as shown by the curves Oc'_0c_0 and $Oc'c$.

The following method of plotting the curves of stresses on the bases Oa_0 and Oa may be found instructive:—Take, for instance, the compression stress curve Oc'_0c_0— At some stress f_0 on Oa_0, the corresponding strain on the curve Ob'_0b_0 is σ. When the curve Ob'_0b_0 coincides with the straight line Ob_0 the strain σ becomes augmented by an amount σ'—the difference between the ordinate to the straight line and that to the curve at f_0—and these two strains $\sigma+\sigma'$ correspond with the stress f_0 and the augmentation f'_0 due to σ'. This new stress $f_0+f'_0$ being plotted as an ordinate to a curve at f_0 on the base Oa_0 determines a point in the required curve of stresses; other points being found in a similar manner and joined, the complete curve of stresses Oc'_0c_0 is formed. The tension stress curve $Oc'c$ on the base Oa can be delineated in a similar manner to that just shown for compression. Now if the point b has been correctly chosen on the tension stress-strain curve, the sum of the stresses within the figure $Oc'ca$ will be equal to the sum of those within the figure $Oc'_0c_0a_0$, and the condition of internal static equilibrium will be observed; in such case the position of the plane of the neutral axis in the beam will be defined by the relation that Oa_0 bears to Oa each as a linear dimension, and not by the relation that F_0 bears to F as stresses.

It will now be convenient to substitute for some of the symbols in *Fig.* 2 others which have special reference to the physical proportions and necessary details connected with the proposed beam which will come under consideration.

In general construction, let *Fig.* 3 (*See page 313*) be similar to *Fig.* 2, with the addition of the reinforcement which is now to be included.

The total depth of the beam is H, and the depth from its top to the axis of reinforcement is D, which is the sum of two parts; v, the distance from the axis of reinforcement to the neutral axis, and v_0, the distance from the neutral axis to the top of the beam.

The vertical distance V is the depth from the top of the beam to the point in the mass of concrete which is effective for purposes of horizontal resistance. Thus, if a crack or other similar defect appeared (as shown in the diagram), the depth or vertical extent of such rupture or defect, $H-V=q$, would be ineffective, and only the depth, $V-v_0=u$, would be effective for purposes of calculating the resistance of the concrete due to tension.

Theory of "Complete Inclusion."—Derivation of the Equations.

The equations now to be proposed will mainly be based on some desired stress, F_0, in compression; they will also depend on the depth, v_0, of the "compression" part of the concrete, the effective depth, V, of the concrete, the depth, D, of the reinforcement below the top of the beam, and the relations between stress and strain in the reinforcement, and in the concrete.

It is required to formulate equations so as to determine the moment of resistance at the section aOa_0, *Fig.* 3, in accordance with the various conditions appertaining to this method in which the whole value of the concrete is utilised, and to this end means must be established whereby the relation between stress, strain, and their connections can be established.

Apparently an equation which will accurately define the precise relation between

stress and strain for any natural material has yet to be promulgated; but one which will, within certain limits, define such relation with fair accuracy is that which is generally termed an exponential form of equation, as follows :—

$$\sigma = Cf_o^{\frac{1}{m}} \text{ for compression and } \lambda = Kf^{\frac{1}{n}} \text{ for tension,}$$

where m, n, C and K are coefficients to be determined by the particular nature of the material under consideration.

Such equations, which have already been used by some Continental writers, do not and cannot be made to express accurately any stress-strain curve throughout its entire range, to whatever degree of refinement the exponents m and n, or the coefficients C and K may be chosen; but beyond low stresses and strains and up to the ordinary working values usually obtaining in practice, they can be made to give results which will agree very well with those derived from experimental tests.

In Fig. 3 the curve $Oc_o'c_o$ represents the "compression" stresses acting on the depth v_o, some definite stress F_o being a known limit. Any other stress f_o at the distance y_o from the axis X_oOX can be found in terms of F_o from the following expression :

$$f_o = F_o\left(\frac{y_o}{v_o}\right)^m \qquad (1)$$

Thus when y_o is equal to v_o then f_o becomes F_o.

The direct relation between stress and strain is thus expressed.

$$\left.\begin{aligned} f_o &= \left(\frac{\sigma}{C}\right)^m \\ \text{whence} \quad F_o &= \left(\frac{\sigma_r}{C}\right)^m \end{aligned}\right\} \qquad (2)$$

The stresses in tension on the concrete are represented by the curve $Oc'c$, and the depth over which those stresses extend is denoted by u. In the first instance, the concrete will be supposed to be sound from top to bottom, and therefore effective for tension from the neutral axis to the bottom of the beam, so that $q = o$ and $u = H - v_o$. Any stress f at the distance y from the axis X_oOX can be found in terms of F from the following expression :—

$$= F\left(\frac{y}{u}\right)^n \qquad (3)$$

The direct relation between stress and strain is thus expressed :—

$$\left.\begin{aligned} f &= \left(\frac{\lambda}{K}\right)^n \\ \text{whence} \quad F &= \left(\frac{\lambda_T}{K}\right)^n \end{aligned}\right\} \qquad (4)$$

The numerical equivalents of the exponents m and n and of the coefficients C and K may be any positive quantities, whole or fractional, which will best suit the purpose for which they are required.

Hitherto the relation between stress and strain has been represented by a curve called the stress-strain curve, but within certain limits such relation may be expressed by a numerical constant termed the "coefficient" or "modulus" of elasticity. This modulus is often practically stated in a very vague manner, so that in one case it may be due to the "total" alteration of length of a test-piece, resulting from the direct action of a known stress or force; in another case it may be due to the "elastic" alteration of such length from a similar cause; and in yet others it may be due to some alteration of length between those two extremes. In reality only the "elastic" change of length ought to be understood, and in such sense it will be employed here. For materials in which the modulus of elasticity—it is sometimes not improperly called the modulus of stiffness—is approximately a numerical constant such a method of combining the relation between stress and strain has considerable advantage. Unfortunately, however, so far as exact science is concerned, the coefficient of elasticity is never a constant for any material; but for practical purposes it is generally assumed

that no great error is committed by supposing it—usually denoted by the letter E—to be a numerical constant up to some fairly well-defined limit of stress, and differing in value only with the differing material it is supposed to represent. The coefficient expressing this modulus of elasticity is stated thus by Rankine :—

$$E = \frac{1}{\textit{longitudinal pliability.}} \qquad \text{(i)}$$

In some metals—especially iron and steel—the stress and strain vary in nearly direct proportion almost up to the limits of ordinary working stresses, and such proportion of uniformly varying stress will be accepted here. Thus for steel, which metal will constitute the reinforcement, the coefficient stated in lbs. per sq. in. is—

$$E_s = \frac{f_s}{\eta} \qquad (5)$$

In (5) the modulus of elasticity E_s is found in terms of f_s and η, f_s being the intensity of stress to be here computed at lbs. per sq. in., and η the alteration in length due to that stress on a prism of the metal originally 1 in. in length. The result of all the internal forces acting in combination at the section aa_0 *Fig.* 3—giving the moment of resistance at that section—is thus determined.

The forces in compression, comprised within the area $Oc_0'c_0a_0$ *Fig.* 3, are to be denoted by A_0.

The forces in tension on the concrete within the area $Oc'ca$ are to be denoted by A.

The forces in tension, due to the extension η of the reinforcement, are to be denoted by A_s.

It is necessary to determine the exact position of the neutral axis at O in the section aa_0.

The condition with respect to the equality of the forces on either side of this point has already been laid down, and in symbols is as follows :—

$$A_0 = A + A_s \qquad (6)$$

The forces in (6) are to be separately determined, the breadth B of the section being now included in the equations where necessary :—

The forces in compression A_0, or the product of the area $Oc_0'c_0a_0$ and B :

$$A_0 = B \int_{y_0=0}^{y_0=v_0} f_0 \, \delta y_0 \qquad \text{(ii)}$$

Substituting for f its value in (1)—

$${}_0 = \frac{B\,F}{v_0^m} \int_{y_0=0}^{y_0=v_0} y_0^m \delta y_0 \qquad \frac{BF_0 \, y_0^{1+m}}{(1+m)\, v_0^m} \qquad \text{(iii)}$$

$$\text{Making } y_0 = v_0 \quad \text{Then } A_0 = \frac{BF_0 v_0}{1+m} \qquad (7)$$

The forces in tension A—in the concrete only—or the product of the area $Oc'ca$ and B :—

$$A = B \int_{y=0}^{y=u} f \delta y \qquad \text{(iv)}$$

Substituting for f its value in (3)—

$$A = \frac{BF}{u^n} \int_{y=0}^{y=u} y^n \delta y :: \frac{BFy^{1+n}}{(1+n)u^n} \qquad \text{(v)}$$

Making $y=u$. Then $\frac{BFu}{1+n}$ (vi)

For the concrete in compression, F_0 is a known quantity; but the unit stress of the concrete in tension F is not known, and it must be put in terms which are or can be known.

In *Fig.* 3 the triangles Oba and Ob_0a_0 are similar, therefore the following ratio holds :—

$$\lambda_T : u :: \sigma_T : v_0 \qquad \text{(vii)}$$

whence

$$\lambda_T = \frac{u}{} \qquad \text{(viii)}$$

Substituting this value for λ_T in equation (4), it is found that—

$$F = \left(\frac{u\sigma_T}{Kv_0}\right)^n \qquad \text{(ix)}$$

In (vi) let F be substituted for its value in (ix);

Then
$$A = \frac{B}{1+n}\left(\frac{\sigma_T}{Kv_0}\right)^n \times u^{1+n} \qquad \text{(x)}$$

But u is a quantity not depending on H, the total depth of concrete, but on the depth of concrete capable of resisting tension—determined by the extent the material

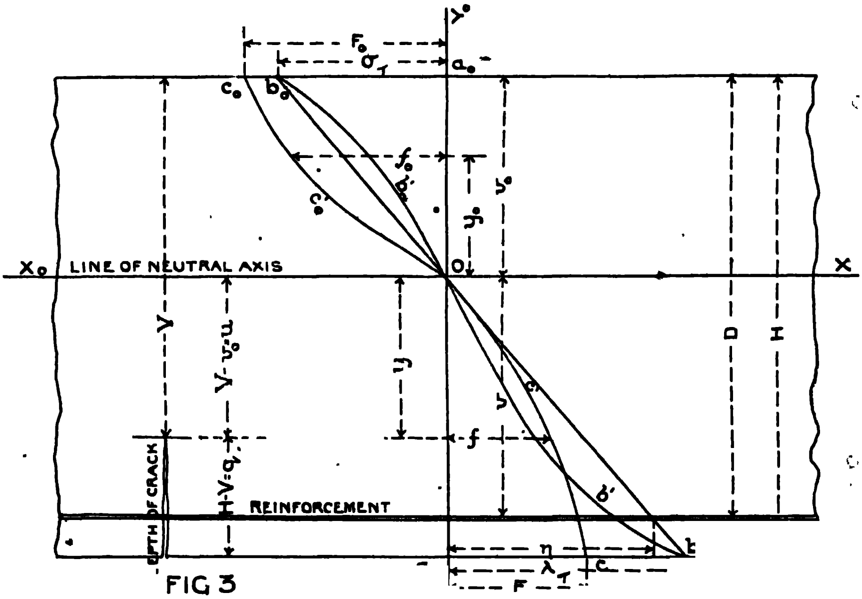


FIG 3

is weakened by a crack or similar loss of cohesion, indicated in *Fig.* 3 and defined there by $V-v_0$.

Then
$$u = V - v_0 \qquad \text{(xi)}$$

Substituting this value of u in (x) and reducing—

Then
$$\frac{B}{1+n}\left(\frac{\sigma_T}{K}\right)^n \times v_0\left(\frac{V}{v_0}-1\right)^{1+n} \qquad (8)$$

The forces in tension—A_s—in the reinforcement, due to the extension η and the sectional area a_s of the metal :—

$$A_s = a_s f \qquad \text{(xii)}$$

In (xii) either a_s or f_s may be supposed known.

In this instance, let a_s, the sectional area of the reinforcement be known. According to *Fig.* 3, the metal has extended an amount η, due to flexure of the beam, and from geometrical considerations the following ratio must hold—the reinforcement being supposed to run normal to the vertical section aa_0 :—

$$\eta : v :: \sigma_T : v_0 \qquad \text{(xiii)}$$

whence

$$\eta = \frac{v\sigma_T}{v_0} \qquad \text{(xiv)}$$

From (5) it is found that $\eta=\frac{f_s}{E_s}$.

Equating these two values of η,

then $$f_s=\frac{E_s\sigma_T v}{v_0}. \qquad \text{(xv)}$$

Substituting this value of f_s in (xii) it is found that—

$$A_s=\frac{a_s E_s\sigma_T v}{v_0}, \qquad \text{(xvi)}$$

Or, as $v=D-v_0$, it will be found convenient to express (xvi) thus—

$$A_s=a_s E_s\sigma_T\left(\frac{D}{v_0}-1\right) \qquad (9)$$

To determine the position of the plane of the neutral axis through the point O, Fig. 3.

Collecting the terms on the right-hand sides of equations (7), (8), and (9) and equating them so as to conform with those in (6), the position of the point O may be found by solving the following equation for v_0 :—

$$\frac{BF_0v_0}{1+m}=\frac{B}{1+n}\left(\frac{\sigma_T}{K}\right)^n\times v_0\left(\frac{V}{v_0}-1\right)^{1+n}+a_s E_s\sigma_T\left(\frac{D}{v_0}-1\right) \qquad \text{(xvii)}$$

As the stress F_0 and its corresponding strain σ_T are both known, it may be convenient to employ a coefficient of elasticity for the concrete in compression for such strictly defined stress and strain and introduce it into the equations.

Thus let E_c represent such coefficient of elasticity.

Then $E_c=\frac{F_0}{\sigma_T}$, and therefore $\sigma_T=\frac{F_0}{E_c}$ (10)

In (xvii) for σ_T substitute its value in (10) and reduce; then—

$$v_0=(1+m)\left\{\frac{1}{1+n}\left(\frac{F_0}{KE_c}\right)^n\times\frac{v_0}{F_0}\left(\frac{V}{v_0}-1\right)^{1+n}+\frac{a_s E_s}{BE_c}\left(\frac{D}{v_0}-1\right)\right\} \qquad (11)$$

This equation (11) cannot always be solved algebraically, but if numerical values are substituted for their corresponding symbols, then v_0, which defines the position of the neutral axis, can be determined to any required degree of approximation by some known method for such purpose.

The position of the plane of the neutral axis through O, *Fig.* 3, having been found, the moments of all the forces about that axis which are acting at the section aa_0 can now be determined.

Let M_0 M and M_s represent the moments about the neutral axis respectively of the resisting forces of compression in the concrete, of tension in the concrete, and of tension in the reinforcement, and let M_R, the sum of all those moments, represent the total internal resistance at the section, thus—

$$M_R=M_0+M+M_s \qquad (12)$$

The moment of resistance of each set of forces may be determined by taking the product of its value, as previously found, and the distance of its centre of resistance from the neutral axis.

For M_0, *the moment of resistance of the concrete in compression.*

$$M_0=B\int^{y_0=v_0} f_0 y_0\delta y_0 \qquad \text{(xviii)}$$

Proceeding in a manner similar to that shown for finding A_0,

$$M_0=\frac{BF_0}{v_0^m}\int_0^{v_0} y_0^m y_0\delta y_0=\frac{BF_0 y_0^{2+m}}{(2+m)v_0^m} \qquad \text{(xix)}$$

Making $y_0=v_0$. Then $M_0=\frac{BF_0v_0^2}{2+m}$ (13)

For M, the moment of resistance of the concrete in tension.

$$M = B\int_{y=o}^{y=u} fy\delta y \qquad \text{(xx)}$$

Proceeding in a manner similar to that shown for finding A.

$$M = \frac{BF}{u^n}\int_o^u y^n y\delta y = \frac{BFy^{2+n}}{(2+n)u^n} \qquad \text{(xxi)}$$

Making $y = u$. Then $M = \dfrac{BFu^2}{2+n}$ (xxii)

For reasons already given with respect to the value of F, let the terms on the right-hand side of equation (ix) be substituted for that symbol in (xxii).

Then $$M = \frac{B}{2+n}\left(\frac{\sigma_T}{Kv_o}\right)^n \times u^{2+n} \qquad \text{(xxiii)}$$

But $u = V - v_o$ and $\sigma_T = \dfrac{F_o}{E_c}$. (By equations (xi) and (10))

Introducing those terms into (xxiii) and reducing, it is found that—

$$M = \frac{B}{2+n}\left(\frac{F_o}{KE_c}\right)^n \times v_o^2\left(\frac{V}{v_o} - 1\right)^{2+n} \qquad (14)$$

For M_s, the moment of resistance of the reinforcement in tension.

$$M_s = A_s v \qquad \text{(xxiv)}$$

Substituting for A_s in (xxiv) its value as given in (xvi) and remembering that $v = D - v_o$.

$$M_s = \frac{a_s E_s \sigma_T (D - v_o)^2}{v_o} \qquad \text{(xxv)}$$

Substituting for σ_T its value, as previously found, and reducing.

Then $$M_s = \frac{a_s E_s F_o v_o}{E_c}\left(\frac{D}{v_o} - 1\right)^2 \qquad (15)$$

For M_R the total moment of resistance at the section.

Collecting the terms on the right-hand sides of equations (13), (14), and (15) and equating them so as to conform with those in (12), then the total moment of resistance at the given section is found to be—

$$M_R = Bv_o^2\left\{\frac{F_o}{2+m} + \frac{1}{2+n}\left(\frac{F_o}{KE_c}\right)^n \times \left(\frac{V}{v_o} - 1\right)^{2+n}\right\} + \frac{a_s E_s F_o v_o}{E_c}\left(\frac{D}{v_o} - 1\right)^2 \qquad (16)$$

With respect to the value of the moment of resistance generally, it is, of course, understood that it must be at least equal to the bending moment.

Other functions, the numerical equivalents of which will be required, are as follows, and they can be deduced from the equations set against them :—

The extension of the concrete at the bottom of the beam	λ_T	from	(viii)
The unit stress on the concrete in tension due to λ_T	F	,,	(4)
The extension of the reinforcement		,,	(xiv)
The unit stress on the reinforcement	f_s	,,	(5)

From the foregoing equations the moment of resistance of a reinforced concrete beam can be determined for any description of concrete or metal reinforcement employed, provided the respective relations between stress and strain are correctly obtained.

The general principles on which those equations are based include the value of the concrete in tension; they are framed in conformity with the laws of elasticity as usually accepted, and the main conditions on which the theory of flexure are based accord with the teachings of eminent authorities on the subject.

Let it be assumed then that results derived from those equations may be considered —at all events for present purposes—as being close approximations to practical and theoretical accuracy.

(*To be continued.*)

THE BUILDING TRADES EXHIBITION, OLYMPIA

The Building Trades Exhibition which took place at Olympia last month was highly instructive and interesting, and, although no remarkable changes have taken place in building methods during the two years which have elapsed since the previous exhibition, a certain development can be observed in the details relating to fire-resisting construction.—ED.

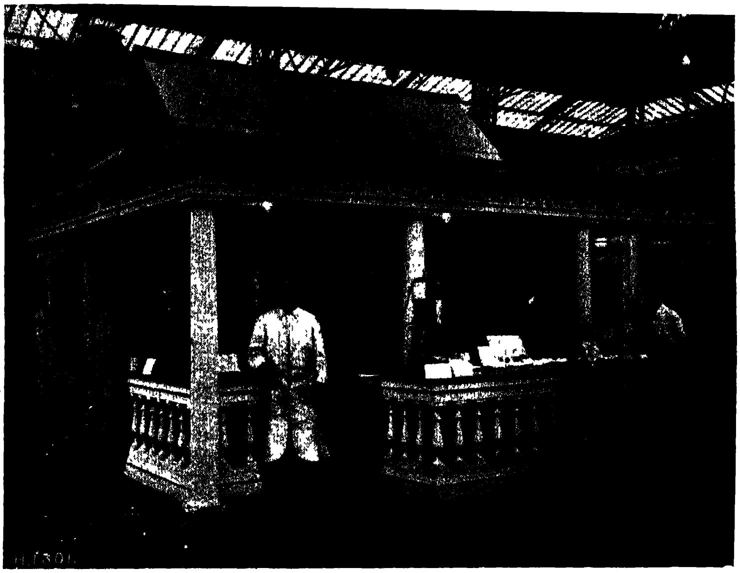
This exhibition presents a unique opportunity to all those interested in the building trade, both professional and practical, for studying numerous points in connection with design and construction, which possibly they have never met with in practice, and almost unconsciously they learn much which is useful, and at a later date, when dealing with a new problem, take advantage of some material or method that first attracted their attention at Olympia.

There is much to be said for these exhibitions; for example, the advantages of any particular system can be so readily understood when explained by a competent person; further, the architect and the specialist are brought in touch with one another in a manner which is only possible on such occasions, while the systematic records of the exhibits cannot fail to be interesting, as they indicate the progress of the science of building, which is a fascinating subject, even to those whose daily occupation does not compel them to deal with these matters.

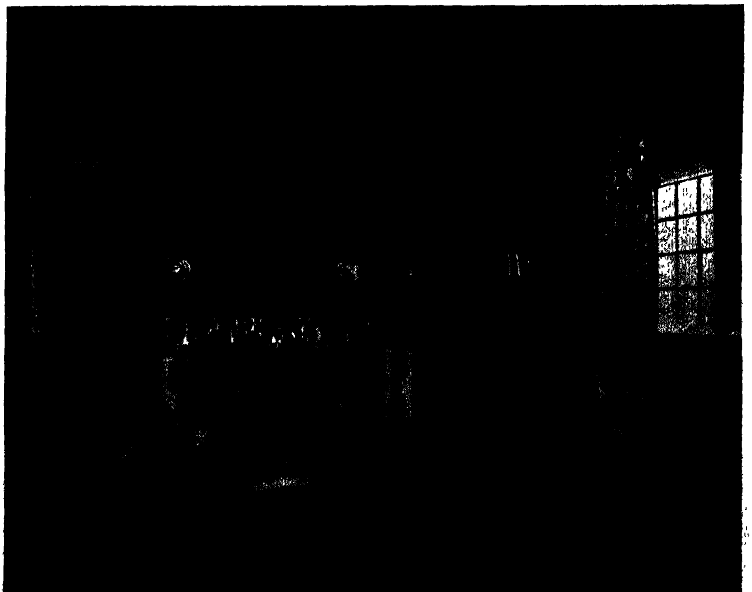
CEMENT.

The value of this material in building work has become so great, owing to the extensive use of reinforced concrete, that it is impossible to lay too much stress on the importance of studying the methods and products of the largest producers of Portland cement in this country, and on the stand of the ***Associated Portland Cement Manufacturers (1900) Ltd.*** (No. 120, row F) there was much of interest. The stand itself is worthy of special mention, it being of pleasing design and well proportioned, as will be seen on reference to the photographic view here shown. The interior was treated with old oak panelled walls and timbered ceilings with large oak beams dividing the latter into three bays, with an ingle nook containing the old-fashioned fireplace at one end. The effect of this treatment was very cosy, and caused one to linger for some time before passing out again into the noise and bustle of the exhibition. The exhibits of the company were excellent and varied, there being samples of their well-known brands of Portland cement, including J. B. White & Bros., Hilton, Anderson & Co., Frances' "Nine Elms," Knight, Bevan & Sturge's "Pyramid," "Anchor," "Burham," "London Portland," "Gillingham," Gibbs' "Diamond," "Eddystone," "Tingey's," "Vectis," "Robins," and also their special "Ferrocrete" brand, which is recommended and highly suitable for all classes of reinforced concrete construction.

The cement is made by most thorough and up-to-date methods, and samples were shown depicting the material at the various stages of manufacture, while there were other samples of cement ground to various degrees of fineness. Many briquettes and cubes of various ages and mixtures for testing purposes were shown, and practical tests were carried out during the exhibition by the aid of a complete testing apparatus which is in conformity with the requirements of the revised British Standard Specification. Of particular interest were the various apparata for determining whether aggregates require washing before use, for ascertaining the proportion of voids in aggregates, and for testing concrete to see if same is mixed in the specified proportions. Another interesting feature was the hydraulic crushing machine used for testing cubes of 50 sq. c.m. area, this reading up to 50 tons and being made at the company's engineering shops from their own designs.



EXTERIOR VIEW OF STAND OF THE ASSOCIATED PORTLAND CEMENT MANUFACTURERS (1900) LTD.



INTERIOR VIEW OF STAND OF THE ASSOCIATED PORTLAND CEMENT MANUFACTURERS (1900) LTD.

Various samples of

other materials were also shown, such as aggregates of all descriptions, both suitable and unsuitable for concrete work, and Plaster of Paris, Keene's, Parian, and Roman cements. Their practical handbook entitled "Everyday Uses of Portland Cement" (3rd ed.), which treats with the economical employment of Portland cement for all purposes, was also on sale on the stand, and, in fact, the exhibits covered all points connected with this material.

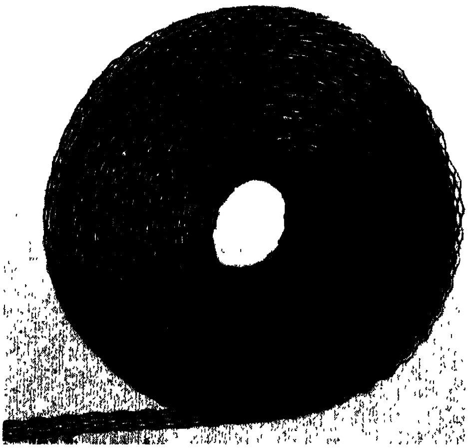
STAND OF THE EXPANDED METAL CO., LTD.

Messrs. Martin, Earle & Co., Ltd., exhibited various samples of their products, including their well-known "Rhinoceros" brand, which is guaranteed to comply with the revised British Standard Specification, and "Ferrodurie," which is specially manufactured for reinforced concrete work and has been largely used for this purpose.

REINFORCED CONCRETE CONSTRUCTION.

The exhibits in this section were not as numerous as might be expected, and this fact was undoubtedly due, in a certain measure, to so many firms being unable to prepare suitable structural exhibits in the short time available for preparation and the absence of ample outdoor space for large exhibits. While several of the leading firms were in evidence, many others, however, did not exhibit.

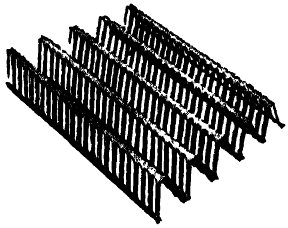
The Expanded Metal Co., Ltd. (No. 157, row G), exhibited examples of expanded steel sheet and bar reinforcement for all classes of constructional work, the stand itself, which is illustrated in the photograph, being formed entirely with concrete reinforced with their materials. One of the great advantages of expanded metal is the ease with which it can be handled and applied, as it consists of stamped metal sheets which are used in conjunction with simple hangers, and as reinforcement it can be applied to footings,



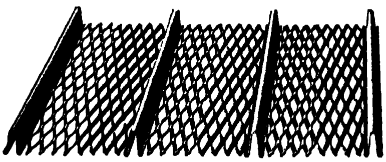
EXMET" REINFORCEMENT OF THE EXPANDE METAL CO., LTD.

columns, flooring, walls, roofing, and in fact any member or structure. It also forms an excellent openwork fence for divisions or machinery guards, etc. The rib mesh expanded steel is a later type of expanded metal, which consists of a series of straight ribs, or main tension members, which, in the process of expansion, are left rigidly connected by light cross ties, which act as spacing members. The usual types of expanded metal used in reinforced construction are the 3-in. diamond mesh in its various weights, and the rib mesh, in which the ribs are constant in cross section, but are spaced at varying centres, thus giving a variable cross sectional area according to the number of ribs in section per foot run. The lighter qualities of the diamond mesh are largely used as a metal lathing for ceilings and all surfaces where a key has to be obtained for plaster, and for this purpose it is preferable to wooden laths. A great advantage of this material is the impossibility of the strands of reinforcement becoming displaced during concreting, as the whole of the reinforcement is in the form of a solid sheet of steel network. Examples of " Exmet " brickwork reinforcement were also shown by the same firm, this material being made in three strengths from 24 gauge, 22 gauge, and 20 gauge best mild hoop steel in coils of practically any length. It is embedded in the mortar between the courses at varying intervals and materially strengthens the brickwork. The use of these materials has become very popular in modern construction, and the firm have innumerable examples for reference.

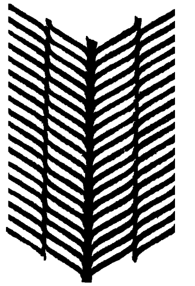
The General Fireproofing Co. (No. 95, row E) exhibited examples showing the application of their " Trusset," " Self Sentering," and Herringbone lath which are used for partitions, floors, roofs, and ceilings respectively, and the nature of which is shown in the illustrations. The stand itself consisted of concrete piers formed of " Self Sentering," supporting, sloping, and flat roof, constructed partly of " Self Sentering " and partly of " Trusset," and concreted over. Suspended ceilings were also exhibited constructed partly in Herringbone lath and partly in " Self Sentering," and a fence was shown



" Trusset."



" Self Sentering."



Herringbone Lath.

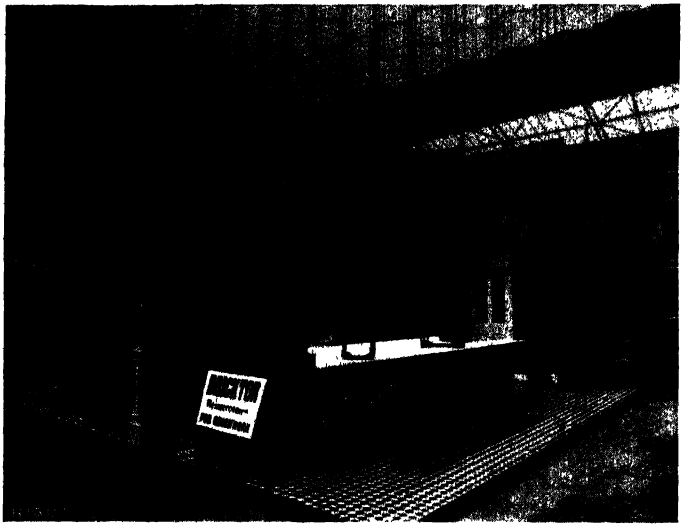
THE GENERAL FIREPROOFING CO., LTD.

constructed of " Trusset " without any temporary shuttering. Partitions formed with each of the three materials could be seen, and also two sections of floors constructed of " Self Sentering," one being of arched form and the other a flat slab.

Messrs. Homan & Rodgers (No. 130, row F).—The exhibits of this firm included their well-known steel and hollow tile floor, which is constructed with hollow tiles about 18 in. long and triangular in section placed between steel joists of a specially light section, and these bricks have a special projecting lip on the underside which covers the flange of the steel joist and may afford some protection against fire. The key for the plaster is afforded by specially formed grooves on the bricks, thus avoiding any hacking. Concrete composed of broken brick or ballast and Portland cement is filled in on the top of the tiles to the required thickness. An example of their patent ferro-concrete floor was also given, and this is constructed of steel rods passing through the main girders to form a continuous tie, thus being a combination of reinforced concrete and steel frame construction. The patent reinforced concrete partition of this firm was also shown, this being made of coke breeze, sand, and Portland cement concrete slabs about 2 ft. 6 in. by 1 ft. 3 in., cast with horizontal steel rods in the top and bottom of each slab. A hole for ⅜th-in. rod is left vertical in the centre of the slab and the rod is inserted at the time of fixing, this projecting about half-way through the groove of the slab above (the slabs being laid to break joint), and then grouted in with cement.

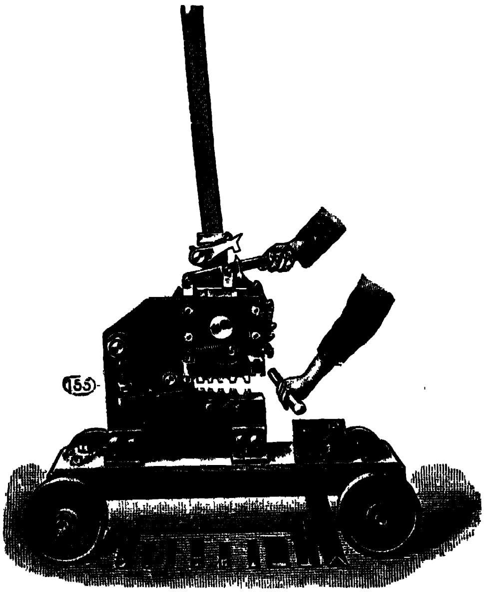
Messrs. Richard Johnson, Clapham & Morris, Ltd. (No. 173, row H).—On this stand were displayed this firm's well-known " Lattice " and " Keedon " system

of reinforced concrete construction, and their "Bricktor" system of reinforced brickwork. This system of reinforced concrete work has the advantage of being very economical while being simple and efficient, and the exhibit was a very good one, as will be seen by the photograph of this stand, where the arrangement of the bars, etc., can be clearly seen. Various samples of "steel wire lattice," as supplied for the construction of the floors in many well-known buildings, were also exhibited. The attention of visitors was specially directed to an improved type of lattice in which the wires where they cross are securely fixed together by a special form of link. 20,000 yards of this material are at present being used in the construction of the new No. 8 Dock Transit sheds for the Manchester Ship Canal Co. The advantages of steel wire lattice for concrete floors are: the ease with which it can be handled and fixed, the continuity of the bond (the material being made up to 200-ft. lengths), and its low cost. The wire used in its construction is of special strength, thus allowing of a minimum depth of slab being adopted, and thereby saving space and dead weight of concrete. The system of reinforced brickwork was well displayed, and examples of walls built upon this principle were exhibited. To demonstrate the lateral strength imparted to brickwork by the insertion of this reinforcement, a heavily-loaded test wall in the form of a slab supported horizontally was erected on the stand.



STAND OF RICHARD JOHNSON, CLAPHAM & MORRIS.

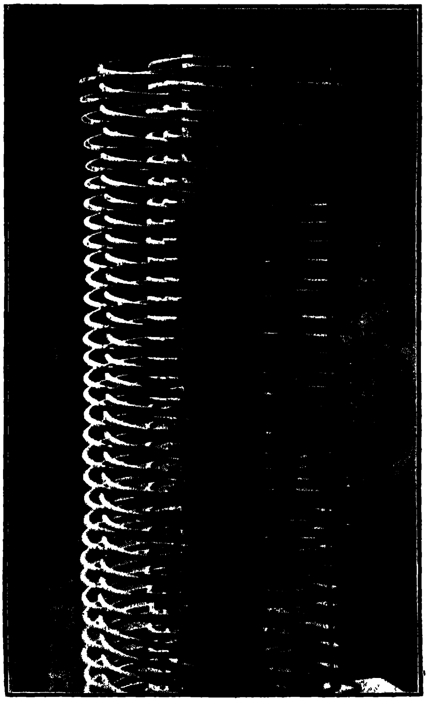
W. Kennedy (No. 45, row C).—These exhibits, although not actual examples of reinforced concrete construction, dealt with the bending and cutting of bars for this work, and they are worthy of special mention. The "Kennedy" bar benders, which are hand-power, portable machines for bending cold bars of various sections for reinforced concrete, were shown, these being of various types, according to the size of the bars to be treated, that listed as No. 2a being worm-geared to bend up to 1½-in. dia. bars, with direct lever for light work. The illustration shows a machine for the expeditious cutting of round bars for reinforced concrete work,



W. KENNEDY'S MACHINE FOR CUTTING ROUND BARS.

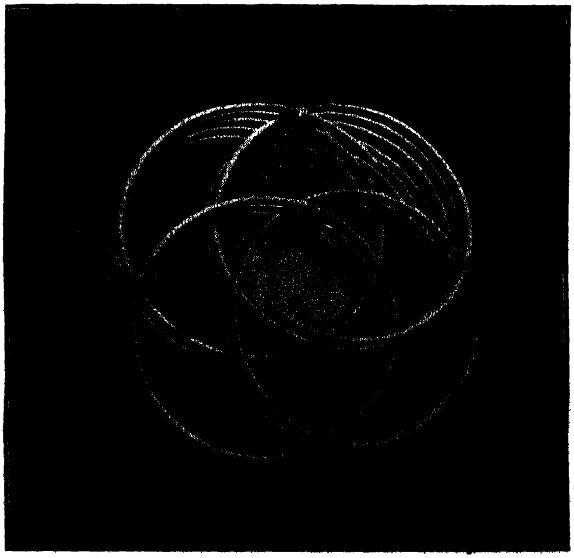
and interchangeable blades can be readily fitted for cropping squares, flats, angles, tees, and other sections. The frame of the tool is formed of a single heavy Siemens-Martin steel plate, and is guaranteed to be absolutely unbreakable, and the longest rods can be readily fed into the machine from the front of the gap. The price of these machines is very reasonable, and the initial outlay is soon regained in the saving of time and labour that is ensured by their use.

Messrs. J. A. King & Co. (No. 112, row F).—This firm are the makers of the well-known "Mack" partitions, and examples of these partition blocks and pugging slabs were shown, together with the "King" pumice concrete fire-, sound-, and vermin-resisting partition slabs, 2 in. to 4 in. thick. Examples of reinforced concrete work were also exhibited, together with their special "Ferro Glass" construction, which is utilised for pavement and floor lights, roofs, partitions, etc. This system consists of specially-made lenses, which are temporarily supported on boarding, while steel rods are introduced in each joint, these rods being continuous and forming a lattice reinforcement, the whole being then filled in with a cement grout. The advantages claimed for this system are that the maximum amount of light is obtained with the maximum amount of strength, and the appearance is good, and exposed metalwork, which always becomes rusty in such positions, is avoided.



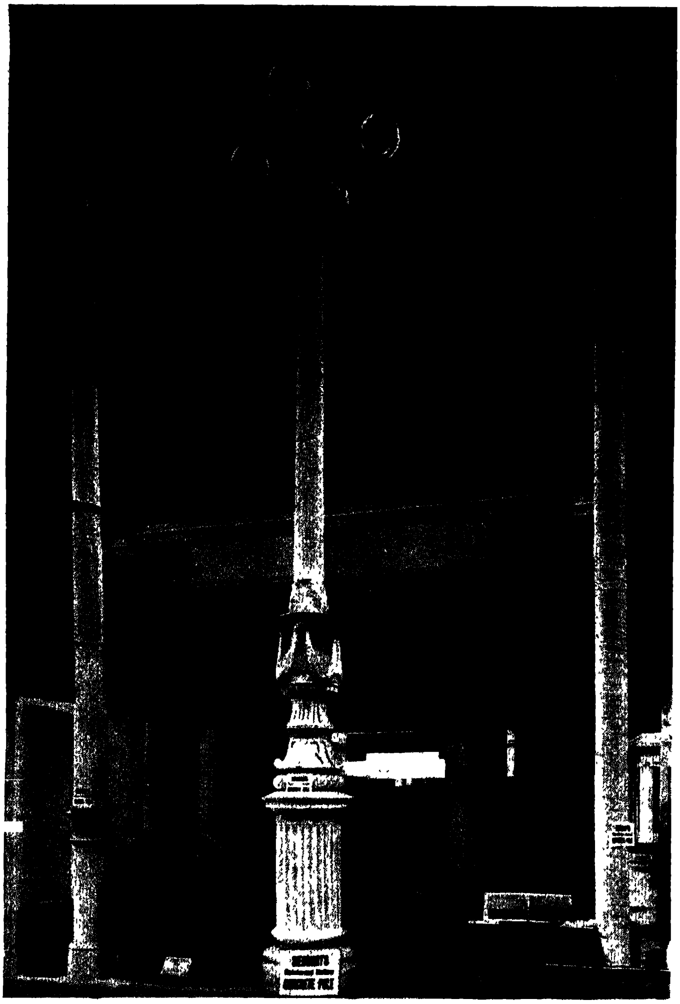
Anchored Spirals, Side View.
REINFORCED METAL, LTD.

Reinforced Metal, Ltd. (Nos. 136 and 137, row F).—This exhibit was particularly interesting, as it showed a new type of reinforcement for columns, and, according to the reports and tests, it is a type which should be largely employed. Various columns were shown, and some of these had been under a test load as great as 1,237 tons per square foot of reinforced area, while others were shown at various stages in the process of construction and some prepared ready for testing. It is claimed by the owner of the patent that these columns have more than double the strength obtainable from any other combination of steel and concrete in which the same weights of these materials are employed. The diagrams show the nature of the construction, with anchored spirals and a central steel core, and it is worthy of notice that the latter is so designed as to be—when braced by the anchored spirals and the encasing concrete shaft—sufficient to carry the whole of the structural load during con-



Anchored Spirals, End View.
REINFORCED METAL, LTD.

struction. It is therefore unnecessary to wait for the hardening of the concrete before proceeding with the floors above, thus enabling buildings to be constructed very expeditiously. An extensive series of tests of columns of this type have been carried out by Professor Andrew Gray, LL.D., F.R.S., Professor of Natural Philosophy at the University of Glasgow, and in the report he says of this method that it "provides a composite material having the remarkable and extremely valuable physical property that its modulus of elasticity under progressive loading increases with the increase of compressive stress." Apart from its practical value, it is thus, on account of this remarkable and unique property, of great scientific interest. Other columns which were tested to destruction carried loads as great as 1,430 tons per sq. ft. of reinforced area. Copies of Professor Gray's report and other particulars can be obtained on application to Reinforced Metal, Ltd., 175, West George Street, Glasgow.



Siegwart's Armoured Concrete Pipes and Poles.

Siegwart, Ltd. (No. 154, row G). The exhibits of this firm included armoured concrete pipes and poles, and the illustration gives an idea of the varied utility of this company's products. The pipes are made as small as 8 in. diameter and as large as 4 ft., and for special work the size could be increased up to 8 or 10 ft. diameter. The concrete and steel are woven together with mathematical precision by machinery and the socket is doubly reinforced; while the whole of the pipe is lined with a special asphalt, also applied by machinery. They are made in longer lengths than other concrete pipes, thereby reducing the number of joints and saving the cost of labour in laying and jointing.

Spiral Bond Bar Co., Ltd. (No. 30a, row B).—Examples showing the application of "Trisec" spiral bond bars for reinforced concrete work of all kinds, which is claimed to be a most reliable and economical type of reinforcement to use, were exhibited by this firm.

The Trussed Concrete Steel Co., Ltd. (No. 154, row G).—The stand of this firm was very attractive, being a pavilion well designed in the Greek style, where the

Doric order was employed, and it was constructed entirely of Hy Rib, which is one of the Kahn products. This material is a steel lathing which is stiffened at intervals of 3½ in. by longitudinal ribs, ⅝-in. projection, thus giving a stiffness which permits of its use as centering as well as reinforcement, and for walls, partitions, etc., eliminating the use of studs. Interesting applications of its use were shown in floor slabs supported by both flat and curved Hy Rib, the various stages of wall construction where it is used with supports, suspended ceilings at 4-ft centres, as compared with the usual 12 in. or 18 in., and centering for circular columns. Sample partition slabs were also shown, and generally the stand was admirably and tastefully arranged.

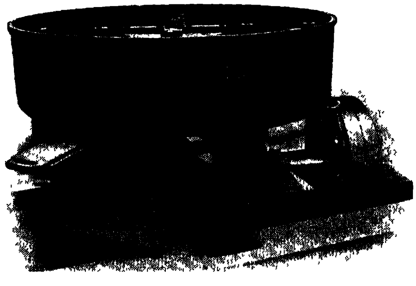
The Vibrocel Co., Ltd. (No. 144, row G).—This firm exhibited for the first time at Olympia, and their stand contained much that was of interest. It is claimed that the Vibrocel method of vibrating concrete *in situ* produces a perfect imbedding of the most complicated forms of reinforcement without risk of displacement, thus securing perfect adhesion and grip. The concrete being rendered non-porous and damp-proof, the reinforcement—however delicate it may be—does not corrode. The examples shown included pneumatic vibrators for vibrating concrete *in situ*, a 5-ft. hexagonal cell of reinforced concrete with walls 2 in. thick filled with water, a similar cell in various stages of construction, specimens of concrete base blocks, pillars, etc., and fragments of 5-ft. cells burst with screw jacks to show that pillar and cell wall unite into one mass without any weakness at their junction.

CONCRETE BUILDING BLOCKS AND MACHINERY.

R. H. Baumgarten (Rep. of the First Cottbus Cement Goods and Machine Works) (No. 128, row F).—Various machines were to be seen on this stand for making all kinds of concrete blocks and tiles. Sand and cement, with breeze or gravel, mixed in various proportions, are the materials used with all the machines, which included types for making concrete roofing tiles, concrete bricks, partition slabs, concrete blocks, and other materials. Demonstrations were given during the exhibition, and the wall of the stand was erected with concrete blocks, while the office partitions and floor were formed with products from the machines. The two illustrations show the nature of some of the machines exhibited.

BAUMGARTEN'S BLOCK-MAKING MACHINE.

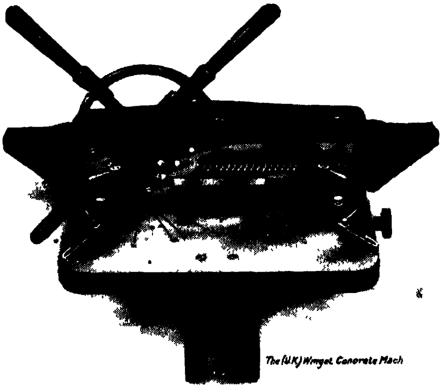
Messrs. Stothert & Pitt, Messrs. F. L. Smith & Co. (Nos. 39 and 40, row C).—There were various types of concrete mixers, both hand and power, exhibited on this stand, including the "Victoria" concrete mixer, with charging hopper, and with loader and water tank, driven by electric motor, and the "Smith" mixer, with charging hopper and a similar type of machine on truck with loader, engine and boiler, with special heating arrangement. Some of the mixers were shown in operation, and the simplicity of the various machines indicated to the visitors.



WINGET "EXPRESS" MIXER.

The (U.K.) Winget Concrete Machine Co., Ltd. (No. 193, row J).—The exhibits on this stand were numerous and interesting, and included the well-known "Winget" concrete block-making machine. This machine was shown in operation making hollow and solid building blocks of a maximum size of 32 in. by 16 in. by 9 in., of which size as many as 500 can be produced in a ten-hour day by one machine. The office on the stand was built with these blocks in order that an idea of the good appearance could be obtained by the visitor, and there need be no monotony in the blocks, as there are no less than nine varying patterns of face available. The "Winget" machine can also be obtained with attachments which allow the production

of partition slabs keyed all round and hollow blocks keyed at the ends, of which two are made in one operation. A smaller and less expensive block-making machine, known as the "Titan," was also exhibited, and this makes hollow or solid blocks 16 in. by 9 in. by 9 in., with plain or patterned faces, with four possible variations of the latter. One of our illustrations shows the "Express" concrete mixer, which was also exhibited in operation. This is a power mixer, and mixes the concrete in any state from dry to sloppy, as desired; it is largely used for concrete block work and for reinforced concrete work, and it has the advantage that the operations of dry and wet mixing are constantly in sight. Other exhibits included a "Winget" hand-power mixer for concrete, and the "Lumsden" wood trimmer, of which an illustration is given. This machine is easily manipulated and gives excellent results, and is indispensable to the pattern maker requiring speedy work. Among the small accessories were shown various concrete laying tools and moulds for balusters and paving slabs.



WINGET "LUMSDEN" WOOD TRIMMER.

Ransome-verMehr Machinery Co., Ltd. (Nos. 218 and 219, row K and bay 26, Gallery).—The exhibits of this firm included a variety of machines for mixing concrete and other purposes, examples of which are shown in the illustrations. The mixers included a No. 0 mixer with direct coupled petrol engine and elevating hopper, large numbers of these being in use at the present time. In addition to this and other power machines, a compact hand-mixer, with charging skip and automatic water tank, was exhibited. Another machine was the Ransome stone dryer, which is utilised for drying stone for making tar macadam, and is so arranged that each batch can be thoroughly dried in three minutes, while the capacity is 50 cu. yds. per day. The example of steel piling and the Ransome pile extractor were of interest, the former being in use at the present time on various contracts, which include the Rosyth Naval Base, the new Port of London Dock improvements, and the new Smith's Dock at South Bank. The cement tester, of which an illustration is given, is designed to supplement the existing tests rather than displace them, and deals with the hardening qualities of the material. The Ransome continuous filter, which was shown in operation, was of particular interest, the water being subjected to the moving sand in such a manner that it is thoroughly filtered, while the filter is simple and economical, with very little maintenance.

BAUMGARTEN'S PARTITION AND PIPE-MAKING MACHINE.

CONCRETE (GRANITE).

Messrs. A. C. W. Hobman & Co. (No. 11, row B).—Various samples of rag-stone for tar paving and tar macadam, and paving samples which had seen many years' wear, were shown, together with examples of "Clifton" artificial stone, "Cliftonite" ornamental paving, and "Emerite" and leaded non-slippery treads for heavy wear.

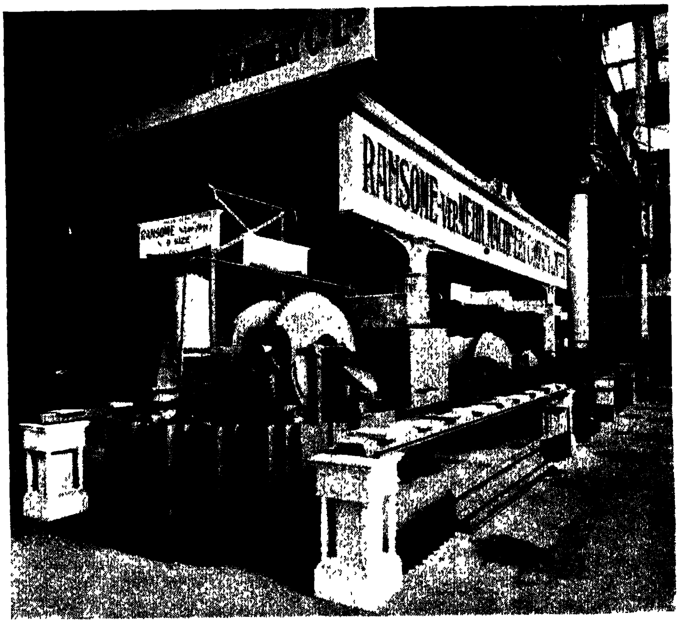
Messrs. Sharp, Jones & Co. (No. 171, row H).—On this stand could be seen various rock concrete sewer tubes and manholes, the latter having the patent "Aquatite" base, comprising benching, channelling, and sewer connections. There were also examples of rock concrete road gullies and rock concrete roofing tiles, the latter requiring no nails, while the double interlocking arrangement assists in the rigidity of the roof.

FIRE-RESISTING FLOORS.

There were several examples of fire-resisting floor construction, and, in addition to those already described under the heading of "Reinforced Concrete Construction," the following are worthy of notice:—

Messrs. Horace W. Cullum & Co. (No. 224, row K).—This system is constructed with special hollow bricks which are used in conjunction with single or crossed reinforcement, and it can be formed with clear spans up to 30 ft. The advantages claimed are: its lightness, rapidity of construction, sound-resistance, and no expansion. The floor can be constructed to carry any load, and when the spans are greater than 30 ft., steel girders are introduced to cut up the floor into panels.

The Kleine Patent Fire-Resisting Flooring Syndicate, Ltd. (No. 119, row F).—The stand of this firm was entirely constructed on their system, which consists of reinforced hollow blocks that can be used over wide spans. It is claimed that this method gives a light form of construction, while it is sound-proof, and it can be rapidly executed.



STAND OF MESSRS. RANSOME-VERMEHR MACHINERY CO., LTD.

The Siegwart Fireproof Floor Co., Ltd. (No. 1, row A).—This system of flooring consists of specially moulded hollow reinforced concrete beams, which do not require any centering, thus avoiding delay on the site of operations and doing away with a large amount of moisture which is necessarily introduced with concrete that is deposited in a moist condition in the work. The beams are placed side by side on the supporting walls or joists, and the joists are then grouted with cement mortar, after which the floor is ready for the finishing surface material. A portion of a constructed floor was shown on the stand, and also the application of the beams to sloping roof work, and one beam was cut to expose the method of reinforcement both for longitudinal stress and shear. The concrete employed for the beams is carefully proportioned and mixed, and the aggregate consists of fine granite.

FIRE-RESISTING PARTITIONS.

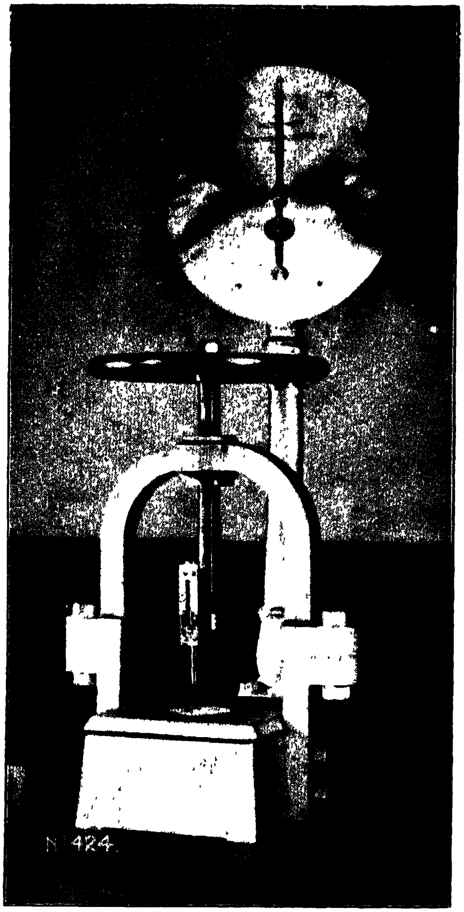
The Muribloc (Partition Slabs), Ltd. (No. 68, row D).—This firm gave a special demonstration of their weight-taking partition slabs, and their exhibit also included samples of their special slabs, such as Muribloc anthracite clinker and cement partition slabs and the Muribloc patent inter-dowel key plaster slabs, with rough and finished faces. In addition to these there were given examples of reinforced concrete lintels, concrete fixing bricks and pugging slabs.

The "Shark-Grip" Tiling Co. (1910), Ltd. (No. 23, row C).—The exhibit of this firm referred to the finishing of partitions and wall surfaces, with regard to cleanliness and hygienic principles, and included examples of the "Shark Grip" (patent backed) tiling, opal tiles, which are guaranteed for five years against facial cracking, crazing, frost, heat, and vibration, and various specimens of terrazzo and mosaic steps and floorings.

There were many other exhibits of fire-resisting partitions, a great number of these being on the stands of those firms dealt with in the other sections, and no further mention or description is needed here.

FIRE-RESISTING DOORS.

Messrs. Chubb & Son's Lock and Safe Co., Ltd. (No. 170, row H).—There were numerous examples of fireproof safes and doors on the stand of this well-known firm, but quite the most interesting was the new patent steel and concrete door, which is suitable for party wall openings and similar purposes. It is made of a solid slab (2 in. thick) of reinforced concrete covered with steel plates, the latter being made to interlock in such a way that the interlocking pieces and the fastening rods inside between the two plates form the reinforcing members of the concrete filling. The concrete is put in from the open ends, which are then closed by end-plates provided with inturned and twisted pieces embedded in the concrete. This new type of construction is to be shortly submitted to a severe test by fire, under the B.F.P.C. rules. It can be adapted for hinged or sliding doors, and for fire-resisting cupboards.



CEMENT TESTER OF MESSRS. RANSOME-VERMEHR MACHINERY CO., LTD.

Messrs. Fireproof Doors, Ltd. (No. 18, row B).—This firm exhibited their "Dreadnought" fireproof doors, which are claimed to have withstood a greater test by fire under the B.F.P.C. standards than any other door. The test comprised an exposure to a temperature of 2,000 deg. Fahr. for four hours. These doors may be treated with panels or mouldings to give any desired effect. The "Empire" fire-resisting doors were also shown, these being somewhat lighter but equally strong, and much used for lifts, staircases, etc., in place of ordinary fire-resisting hardwood doors. There were also examples of the "Dreadnought" cabinets displayed, these being employed for the safe keeping of papers, etc.

ROOFING AND WATERPROOFING.

Messrs. D. Anderson & Son, Ltd. (No. 133, row F).—The exhibits on this stand included many roofing and preserving materials, such as the "Rok" roofing, "Stoniflex" felts, "Zerolite" insulating papers, "Sanador" felt for sarking purposes, "Sideroleum" wood preservative, and "Siderosthen" anti-corrosive paint.

The British Ceresit Waterproofing Co., Ltd. (No. 210, row J).—This exhibit took the form of a small model house built in Ceresit-cement-mortar, and a few slabs with glass cylinders attached containing water and Ceresit-cement buckets. The small model was made to revolve in water, and was washed over with water by means of pipes attached to the building in order to show the waterproofing qualities of the material.

Messrs. George M. Callender & Co., Ltd. (No. 64, row D).—A number of waterproofing specialities were exhibited at this stand, one of the most notable of these consisting of a reservoir rendered watertight with Callender's sheetings, which are adapted for tanks, sub-basements, swimming-baths, and similar constructions. A

model was also shown as an illustration of the waterproofing qualities of "Protex" when applied to a brick surface, which was played upon by water jets as a practical illustration. Other specialities included their various damp courses, "Bitusol" paint for iron and steel work, "Bitubond," for pouring into cavity walls to render them temperature-proof, and their "Veribest" natural asphalt roofing.

The Ironite Co., Ltd. (No. 214, row J).—The exhibit of this firm consisted of examples showing the various applications of "Ironite," which is a fine mineral powder that is mixed with water and applied to concrete or brickwork to fill the voids and render the material impervious to moisture.

Messrs. Kerner-Greenwood & Co. (No. 33, row C).—On this stand the visitor could see models, etc., erected for the purpose of showing the waterproofing qualities of "Pudlo," which is used in the form of a white powder that is mixed with the cementing material. There was a model house built with ordinary brickwork and rendered externally with Pudloed cement, upon which a constant stream of water was allowed to play, and also a model flat roof holding water, and other examples which put a severe test on the material without producing any effect as regards the percolation of water. It is claimed that this material has no detrimental effect on the cement with which it is mixed, and, in fact, it slightly increases both the tensile and crushing strength of the cement used.

Messrs. F. McNeill & Co., Ltd. (No. 103, row E).—On this stand were shown various roofing felts and sheeting, including the various types of the "Lion Brand" and "Lakumen," and other materials for roof lining and sound deadening.

The Ruberoid Co., Ltd. (No. 152, row G).—The exhibit of this firm consisted of a building whereon were displayed the various applications of "Ruberoid" roofing to flat and pitched roofs. This material has been largely employed during the twenty-one years it has been on the market, and it is the only prepared, flexible coloured roofing that is manufactured. It can be applied to any kind of roof work. It is interesting to note that the composition of the material has not been altered in any way since it was first manufactured in 1891, although the firm have never ceased their researches since the material was first invented.

Messrs. Vulcanite, Ltd. (No 105, row E).—Various models illustrating the application of patent vulcanite roofing and "Rexilite" roofing were given on the stand of the firm, who also exhibited their Bitumen Bridge asphalt and Standard asphalt for cavity walls, together with many other specialities.

STEEL PILING AND METAL DOORS.

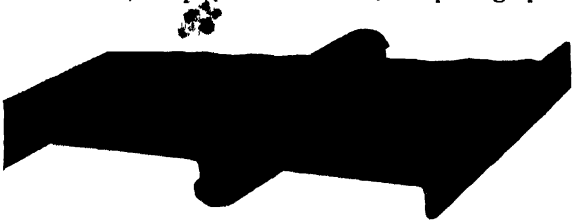
"Simplex" Piling.

THE BRITISH STEEL PILING CO.

The British Steel Piling Co. (No. 7 Bay, Gallery).—The exhibit of the firm included various types of steel piling, such as the "Universal" joist steel sheet piling and the "Simplex" piling. The former type consists of various sections of rolled steel joists which are connected with special shaped clutches, and the latter is formed with a special section with interlocking flanges. The firm also make a speciality of pile-driving equipment, and have carried out the piling work on many important contracts. Steel piling is being largely used for important work in the present day, as there is no waste in cutting, it is much stronger and more reliable than timber, and can be driven more cheaply. The sections can be used a large number of times, and when finished with as piling will always find a ready market as scrap. The Blaw collapsible steel centering is another speciality that was shown, and this is adopted for centering for sewers, culverts, conduits, etc. The general principle of the "Blaw" system is simply steel sheet held at the curvature, by means of angle irons, etc., and turn-buckles. These turnbuckles on being screwed tighter, must necessarily gently reduce the span of the cross diameter when they are fixed, and as the centres as a whole (in the case of arch work) are supported on wedges, when the wedges are loosened it follows that the whole centre must come away from the finished work gently. This is a very good system to adopt, as it is simple, saves time and money, and gives a finer

finish to the concrete than any timber centre. The firm have numerous examples where their systems have been employed, which are good evidence as to the efficiency of their products.

The Art Metal Construction Co. (No. 104, row E) showed various steel furniture and fireproof construction, the photograph illustrated being that of a typical exhibit. The specimens were very varied, and included partitions, screens, adjustable shelving, and steel fittings in general, and some "Dahlstrom" doors, which were recently submitted for official fire test under the B.F.P.C. rules and obtained the 2½-hour classification.



UNIVERSAL JOIST STEEL SHEET PILING.

The Delta Metal Co., Ltd. (No. 174, row H), are the largest manufacturers of extruded metals, and they exhibited specimens of almost every section imaginable. This company do not make finished articles, but only supply their semi-manufactured specialities to the trade.

The Crittall Manufacturing Co., Ltd. (No. 161, row H), showed metal windows of every description, and their exhibit took the form of a building specially erected for the purpose of showing the various types in position in the work. Examples of fire-resisting doors were also to be seen.

ASBESTOS SLATE FOR TILING.

There were many exhibits by firms supplying these materials, amongst them being ***The Asbestos Slate and Contract Co.*** (No. 82 and 83, row E), whose exhibit consisted of a bungalow; ***Messrs. Bell's United Asbestos Co., Ltd.*** (No. 168, row H), who were the first to manufacture "Poilite" Asbestos Cement tiles and sheet in Great Britain under the first Patent Act to be revoked under the new Patent Act of 1907; ***The British Uralite Co. (1908), Ltd.*** (No. 108, row E), who exhibited a whole building specially designed to show the adaptability of "Uralite"; ***The Calmon Asbestos and Rubber Works, Ltd.*** (No. 29, row C), who showed their well-known Calmon Asbestos roofing tiles, wall and ceiling sheets; and ***Messrs. G. R. Speaker & Co.*** (No. 63, row D), whose exhibit consisted of a wood and steel framed building covered with their "Eternit" slates and lined throughout with Speaker's "Eternit" sheets.

VARIOUS.

Messrs. Cassell & Co. (No. 50, row D), the publishers of *Building World*, exhibited copies of this technical journal, together with various technical books, including their recently-published book, *Cassell's Reinforced Concrete*, which appears to be having a good sale.

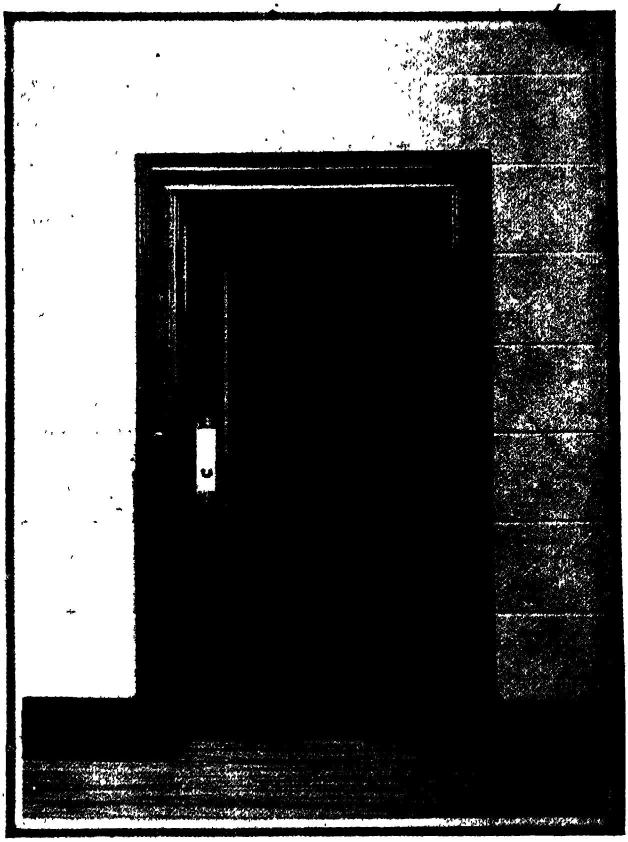
The Compendium Publishing Co. (No. 194, row J) were exhibiting their publications, *The Engineers', Architects' and Contractors' Compendiums*, and the *Compendium Registers.*

Hudson & Kearns, Ltd. (No. 135, row F) had an attractive stand where the visitor could inspect various specimens of art and general printing, and drawing and tracing materials.

There were many more interesting objects, but lack of space prevents their being described or even mentioned, and the organisers are to be congratulated on the excellence of the exhibits. We feel that a written description can hardly do justice to the work shown, which reflects great credit on the various firms responsible for their arrangement.

In conclusion we would add that, as on previous occasions, the organisers gave every opportunity to the various technical societies interested to make a careful study of all there was to be learnt regarding building construction by issuing special invitations to the membership of these institutions, and among those societies who enjoyed the courtesy of the authorities were :—The Institution of Municipal Engineers, the Institute

of Builders, the District Surveyors' Association, the Institute of Clay Workers, the Royal Sanitary Institute, the Society of Architects, the Surveyors' Institution, the Concrete Institute, and the Institution of Heating and Ventilating Engineers.



TYPICAL EXHIBIT OF THE ART METAL CONSTRUCTION CO.

PROVISION WAREHOUSE IN REINFORCED CONCRETE.

The warehouse described below contains many features of particular interest, and goes to show that reinforced concrete is admirably adapted for buildings of this kind where food has to be stored in large quantities and sometimes for considerable periods.—ED.

THERE has recently been completed near the south end of Blackfriars Bridge, London, for Mr. J. Sainsbury, Provision Merchant, a building which is certainly one of the largest reinforced concrete warehouses in London.

Not only does the use of reinforced concrete for this important structure afford one more proof, if such were required, of its economy and suitability where heavy loads have to be carried, and where protection against fire is a *sine quâ non*, but the idea which seems to be current in some quarters that reinforced concrete is not a material which lends itself to quick construction has also been completely refuted. Throughout the progress of the work it was noticeable that the other trades were keeping back the concrete work rather than *vice versa*.

The building, which is adjacent to the large previously existing premises of Mr. Sainsbury, is situated in Bennett Street and Stamford Street, being only about 100 yds. from the south bank of the Thames. It consists of seven floors and the roof, the outside walls being of masonry and brickwork, and the whole of the internal framework, footings, columns, beams, floors, staircases, etc., of reinforced concrete. The retaining walls supporting the roadways and footpaths in Stamford Street and Bennett Street are also of reinforced concrete, and are of a somewhat unusual design, which is described later.

Owing to their proximity to the river, considerable difficulty was experienced with the foundations, portions of which had to be carried below the level of the water in the gravel. At one spot the inrush of water was so great, and the consequent disturbance of the gravel and sand of which the foundations are formed so serious, that it was necessary to resort to piling, but as a general rule the footings, both of the piers carrying the walls and of the interior columns, were designed of reinforced concrete in such a way that the load upon the gravel below was not more than could safely be carried by it without further assistance. Two heavy internal walls cross the building, and the footings for these were, of course, continuous slabs, the sections of which are seen in the longitudinal section in *Fig.* 1. But, in addition to the two wall footings, wherever possible two or more columns were carried on a single strip footing in the form of an inverted tee beam. The sections of these are shown towards the right-hand side of the longitudinal section just referred to.

A considerable economy, both of space and material, is effected by this

type of design, which has the further advantage of tying the bottoms of the columns together and thus stiffening them. It will be noticed that the footings are not all at the same level, the variation being due to the varying nature of the material as well as the requirements of the building.

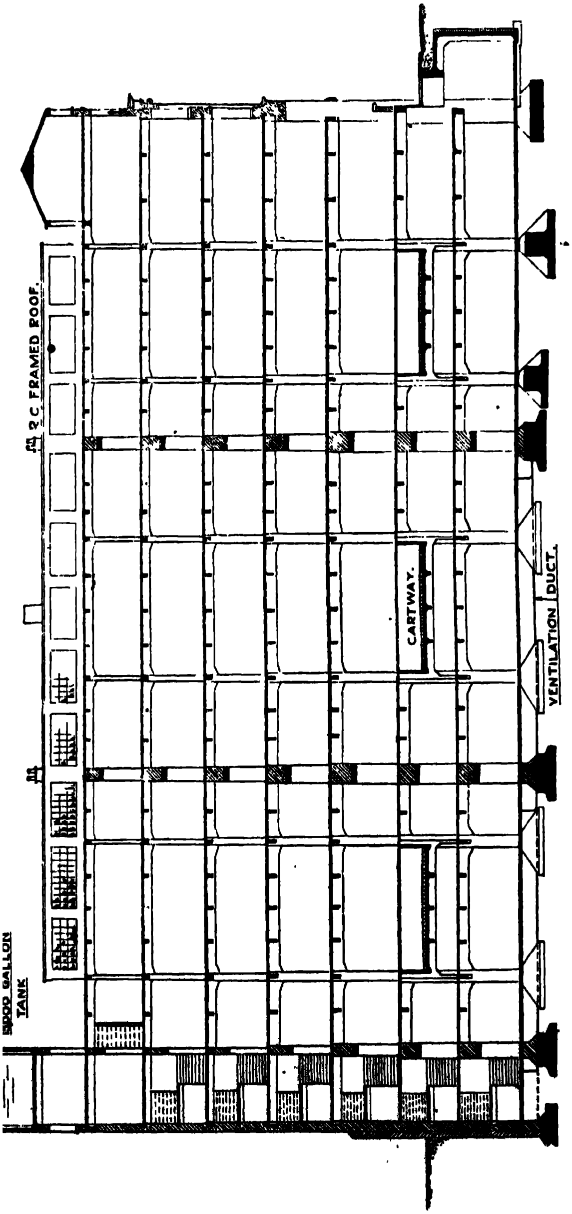


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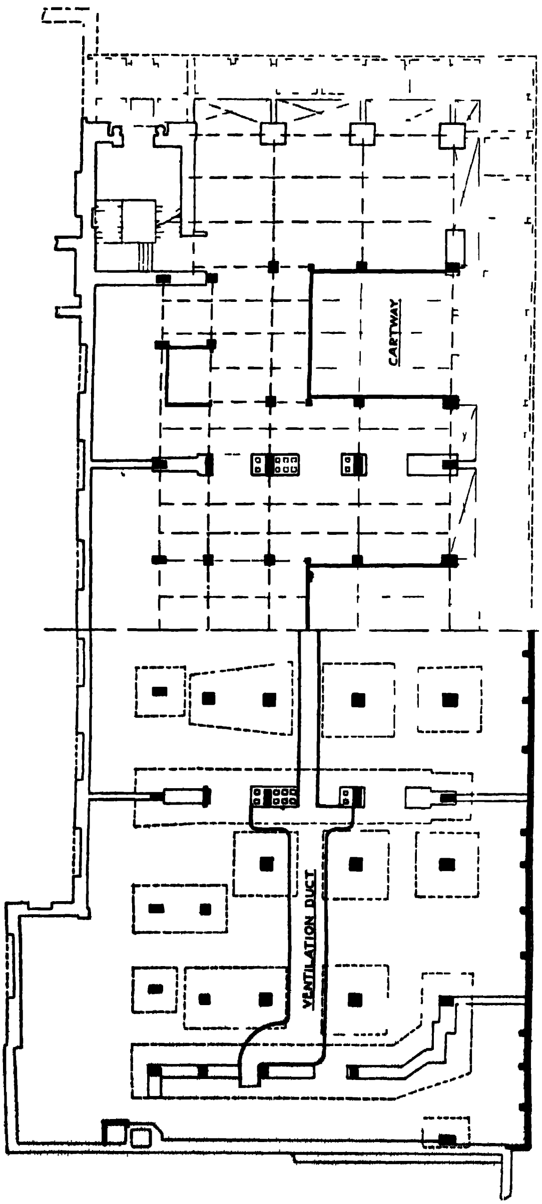
Fig. 1. LONGITUDINAL SECTION. W. [illegible] IN REINFORCED CONCRETE.

The basement is approximately 187 ft. long by 75 ft. broad, and is surrounded on the two sides next the streets by retaining walls of reinforced concrete. The design of these walls consists of a slab varying in thickness from 6 in. to 8 in., supported by a system of vertical beams 10 in. by 10 in., which are supported at the bottom by the floor of the basement, and at the top by horizontal beams, some of which run into the main columns of the building. These horizontal beams also support the slab carrying the load of the pavement and street above, this slab acting as a beam from column to column to resist the horizontal thrust of the ground against the retaining wall.

The intermediate beams which do not run directly on to the main columns of the building are supported vertically at their inner ends by a longitudinal beam running parallel to the wall, and supported in turn by those of the cross beams which run on to the main columns. (See *Figs.* 1 and 4.)

It may be mentioned that, owing to the heavy nature of the traffic in the neighbourhood, the requirements of the district surveyor were very heavy in the

case of these retaining walls and the pavement and road slabs supported by them, a load of no less than 10 cwt. per sq. ft. having to be carried by the floor below the pavement, while the retaining wall had to withstand a super load of the same amount in addition to the load of the ground itself.



HALF PLAN AT CARTWAY

HALF BASEMENT PLAN

Fig

It was, of course, necessary, under the London County Council regulations, to asphalt the back of the retaining wall, and in order to facilitate this a somewhat unusual method was adopted, which proved very satisfactory, and will probably be used more frequently in future. The method consisted of building a thin 4½-in. brick wall in small portions against the ground, and carefully retimbering this brickwork as soon as it was complete. Just before the reinforced concrete wall was placed in position the brickwork was covered with asphalt, and the concrete then placed against it. This method avoids the waste of space and the difficulty and cost of refilling without danger of subsidence, which always exist when sufficient space is left outside the retaining wall to place the asphalt directly on the back of the wall.

The floor of the basement over the sub-basement presents no special details, but the ground floor over the basement contains three loading cartways leading in from Bennett Street, and at the same level as the street—*i.e.*, 4 ft. below the level of the ground floor. These cartways are designed to carry the heaviest form of motor lorries. They

are supported by main beams 18 in. by 18 in., each carrying three secondary beams 14 in. by 8 in.; the slab between the secondary beams being 5 in. thick and covered with 4-in. granite cubes to afford a foothold for horses. The sides of the cartways run direct into the columns and themselves form secondary beams carrying the outside bays of the slab. (See *Figs.* 3 and 4.)

The first floor, being unbroken throughout its area, may be taken as typical of all the upper floors.

The live load is in all cases 4 cwt. per sq. ft., this exceptionally large figure being due, of course, to the heavy nature of the goods to be stored.

The main beams run parallel to the length of the building, which is divided into three portions by two main division walls of brick running right across the building from top to bottom. Each division of the building contains three consecutive spans of main beams, the centre of which is the greatest, 22 ft., the small spans being 16 ft. and 12 ft. in the centre and outside division respectively. The long span main beams are 18 in. by 10 in. and contain two $1\frac{1}{2}$-in., four $1\frac{1}{4}$-in., and two $\frac{5}{8}$-in. bars.

The secondary beams are nearly all 14 in. by 7 in. and contain two $\frac{7}{8}$-in., two $\frac{3}{4}$-in., and two $\frac{5}{8}$-in. bars.

The slab is $4\frac{1}{2}$ in. thick, and is covered by a 1-in. thickness of granolithic to form a finish. This granolithic was put on as nearly simultaneously with the slab as possible, so that it should be monolithic with it.

At the back of the building—that is to say, on the side opposite Bennett Street—the last bay is broken up to a considerable extent to allow of lift wells,

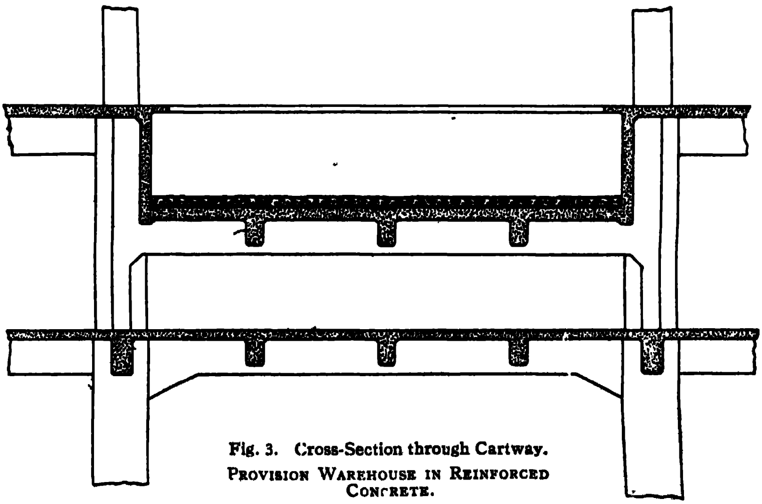


Fig. 3. Cross-Section through Cartway.
PROVISION WAREHOUSE IN REINFORCED CONCRETE.

etc. These lift wells are enclosed by slabs of reinforced concrete 3 in. thick, reinforced by a network of light bars running both horizontally and vertically.

The N.W. and S.E. corners of the building are occupied by the staircases, which are of reinforced concrete formed *in situ,* and do not present any very special features, although a considerable number of cranked beams occur in which the reinforcement is somewhat intricate.

The roof is well shown by *Fig.* 7.

The centre bay for the greater part of the length of the building is raised by light trusses of reinforced concrete, so as to admit of glass lights being inserted between the flats at the two levels. Three trusses occur at 11-ft. centres, and are supported on main longitudinal beams, 27 in. deep, reinforced by two ⅞-in., two ¾-in., and two 1-in. bars, and a tie, 9 in. by 6 in., occurs at each column. The secondary beams supporting the flat portions of the roof are 6 in. by 5 in., with three ¾-in. and two ⅜-in. bars. The slab is 3 in. thick.

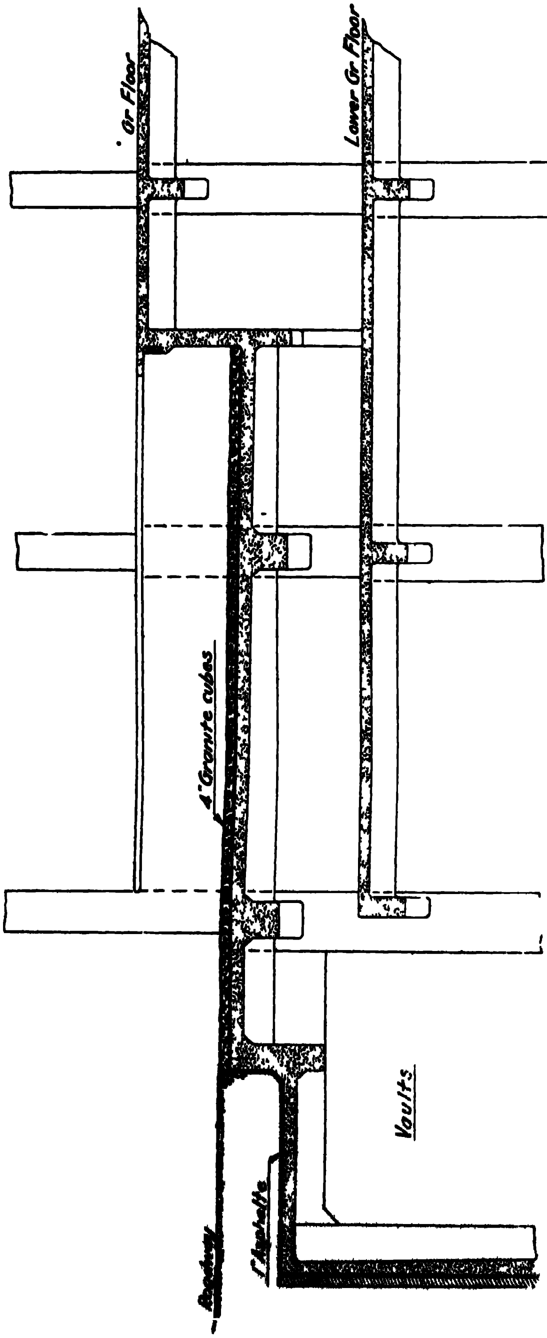


Fig 4. Longitudinal Section through Cartway

Portions of the building are raised to another floor, forming a dining-room and chambers containing lift machinery, etc. There is also a reinforced concrete tank to hold 15,000 gallons.

As might be expected in a building of so many floors carrying such exceptionally heavy loads, the size of the columns required in the sub-basement, basement and ground and first floors was found to be excessive if only the ordinary percentage of steel was used. It was therefore decided to increase the amount of steel and thereby reduce the size of the columns. In the largest column no less than twelve 1¾-in. bars were used.

The junction of the column bars at the various floors was effected in

the usual way by lapping the bars in all outside columns, or wherever the column could conceivably be subjected to bending stresses; but in the interior columns, where there is no possibility of any bending, loose sleeves were used, by means of which the ends of the bars were joined, thus saving space and allowing more room for concrete. This point is of considerable importance where there is a mass of steel running into a column horizontally from four directions, and where, at the same time, there may be as many as twelve vertical column bars in a small space; but, of course, it is an extremely dangerous method if there is the least possibility of any bending stresses occurring in the columns, as some

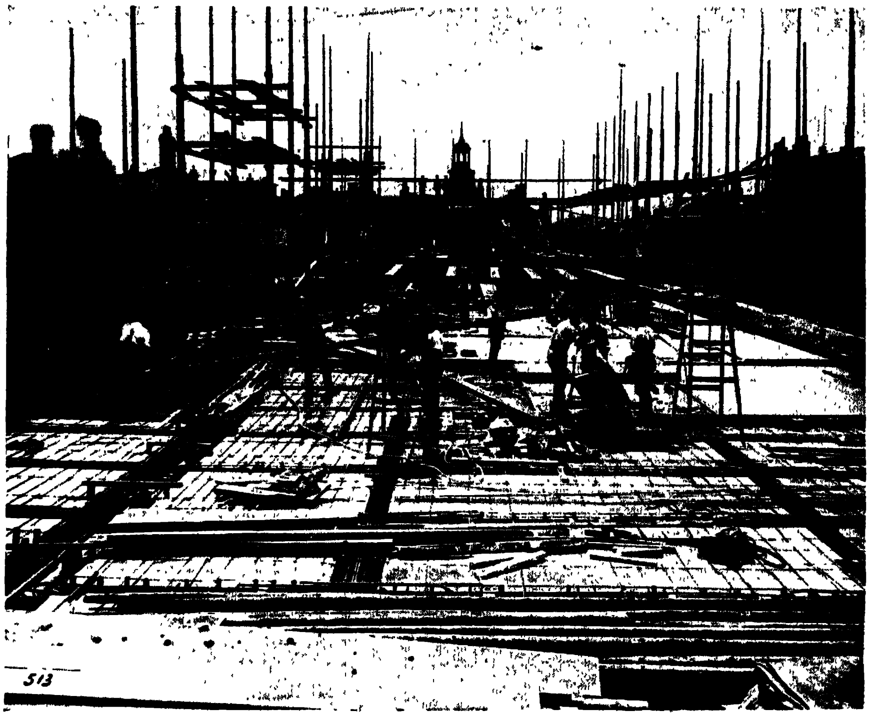


Fig. 5. View of Floor in course of construction.
PROVISION WAREHOUSE IN REINFORCED CONCRETE.

of the bars might then be put into tension. The "sleeve" method gives practically no tensional strength.

A test load of 1½ times the working load was applied to three floors simultaneously, so as to test not only each floor, but the columns and foundations at the same time. This is a point which is too often ignored.

It is interesting to note the extremely small deflection under load which is nearly always obtained with a well-designed reinforced concrete structure. In this case the maximum deflection of the main beams did not exceed 1/5400 of the span.

The work was carried out by Messrs. W. Johnson & Co., Ltd., Wandsworth Common, from designs prepared by the Indented Bar and Concrete

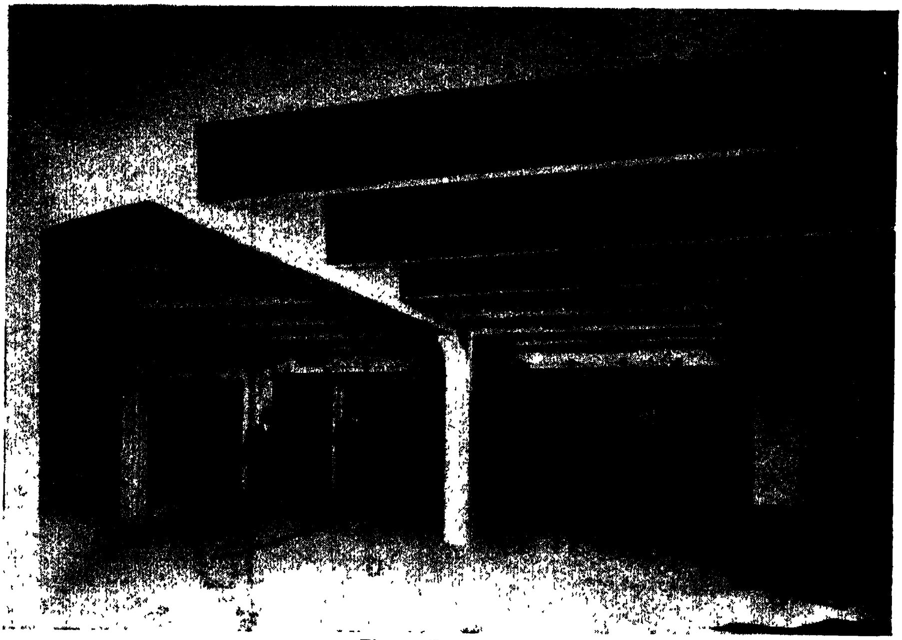


Fig. 6. Fourth Floor.

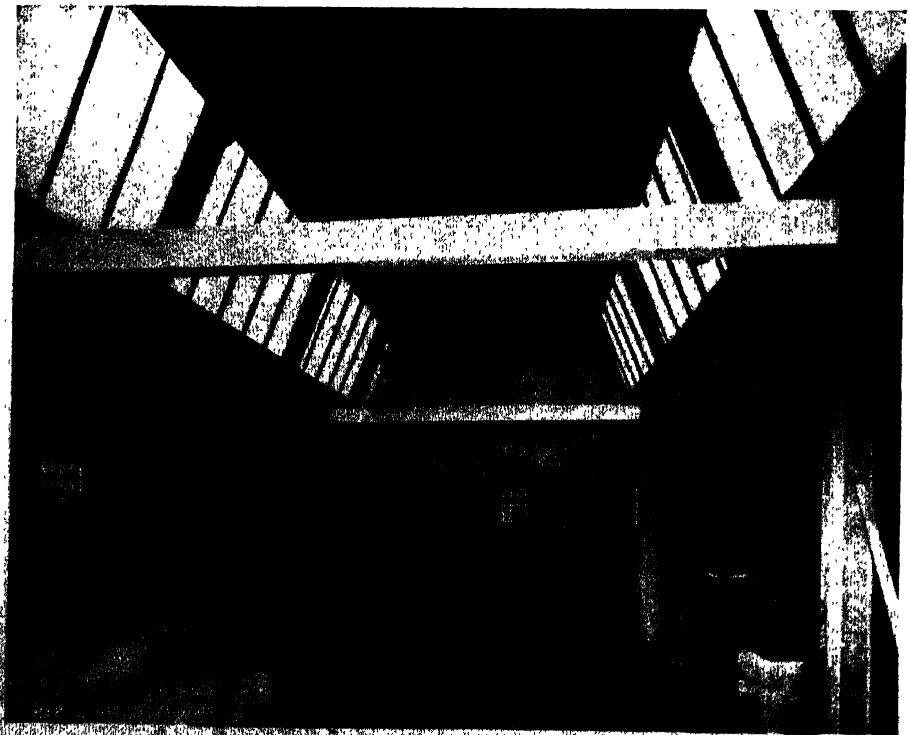


Fig. 7. Interior View of Roof.
Provision Warehouse in Reinforced Concrete.

Engineering Co., Ltd., Queen Anne's Chambers, Westminster, the whole being under the direct superintendence of the architect, Mr. A. Sykes, F.R.I.B.A., of Finsbury Pavement, London, E.C.

The various photographs, excellent as they are, hardly convey sufficiently the clean and light appearance of the building, which has been obtained by the

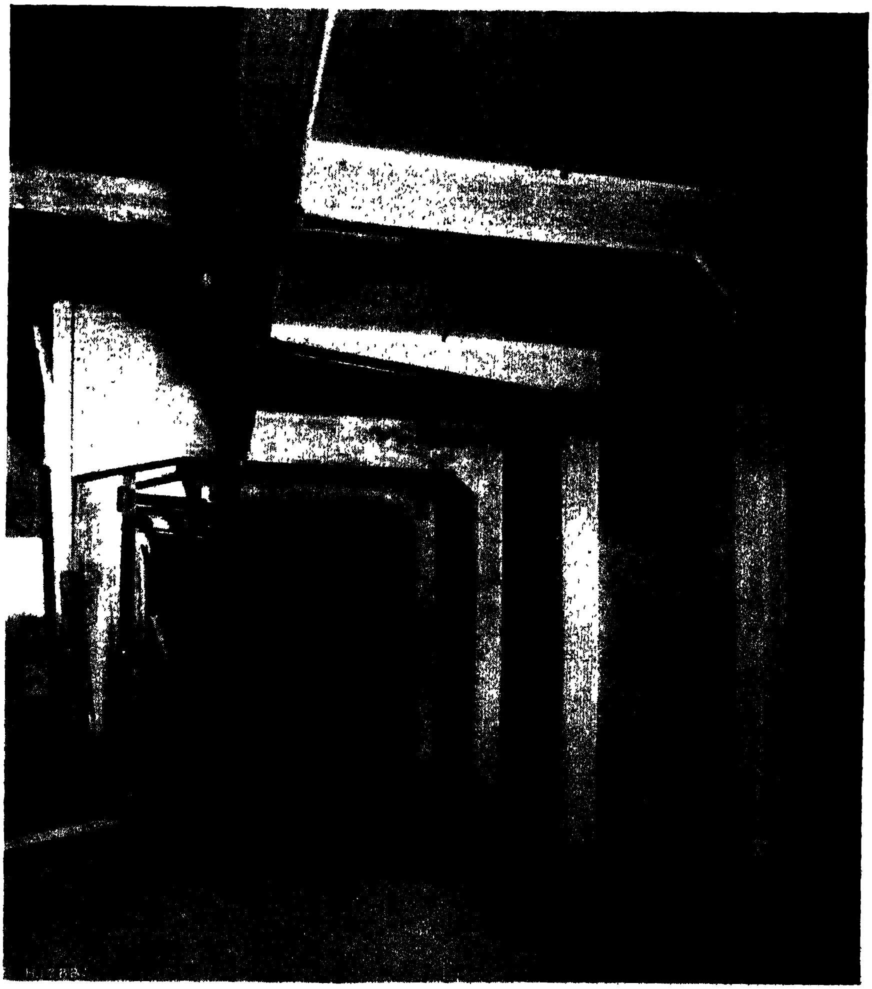
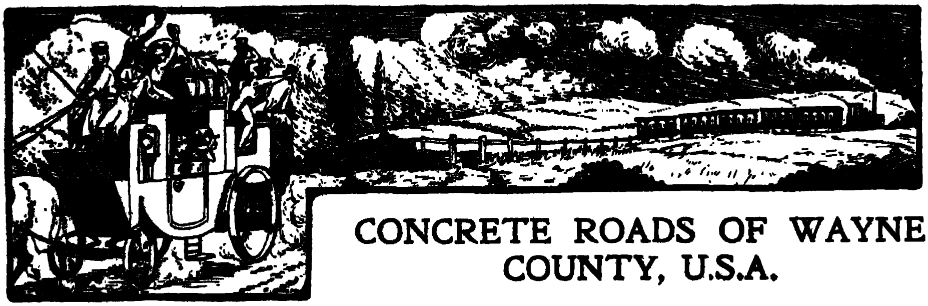


Fig. 8. Basement Retaining Wall.
PROVISION WAREHOUSE IN REINFORCED CONCRETE.

use of reinforced concrete. In spite of the very heavy character of the loads to be carried in buildings for such purposes as the storage of articles of food, it is hardly possible to lay too much stress on the value from a sanitary point of view of a clean reinforced concrete job such as this.



CONCRETE ROADS OF WAYNE COUNTY, U.S.A.

By EDWARD N HINES.

In view of the impending International Road Congress to be held in June next, and regarding which a note appears in another column of this issue, we give below a Paper read on the subject of concrete roads at the Ninth Convention of the National Association of Cement Users, Philadelphia, Pa.—ED.

It is a sad commentary on the conduct of an undertaking of any magnitude that individuals, municipalities, states or nations, all seem to find it necessary to do a certain amount of experimenting and dilly-dallying before accepting the conclusions and avoiding the failures of previous demonstrations.. This is particularly true of the various phases of the good roads movement.

With four years' experience as a guide, it has been demonstrated in Wayne County (Mich.) that a well-built concrete road is a practical form of construction which merits and will receive a more extensive adoption. Every test to which our work has been subjected serves only to emphasise its strong characteristics. The points considered, which might properly be termed a specification, are: Initial cost, ultimate cost (which includes maintenance), sanitation and freedom from dust, good traction for all types of vehicles, smoothness and ease of construction.

The initial cost of a good concrete road is little, if any, greater than that of a first-class bituminous macadam road. One of the greatest fallacies indulged in by communities starting to improve their highways is that cheapness in cost of original construction of roads means economy and that the highway official who can build the greatest area of roads at the least outlay per square yard is working for the community's best interest.

THE PAVING DETERMINATOR.

About a year ago, as a result of the rapid deterioration of new pavements, the Citv of Detroit conducted an inquirv into materials used and methods followed in paving, and the Common Council of the city voted $600 for testing purposes to decide the merit or lack of merit of the various forms of built-up pavement. Boiler Inspector McCabe designed a very ingenious machine whereby all the conditions met with in street traffic could be reproduced as nearly as possible.

The machine is made to revolve about a vertical shaft which carries, on a bearing, a head, which forms a bearing for the steel frame, at each end of which are jointed T castings. These T castings carry the shaft upon which solid cast iron wheels are mounted. The wheels have a 3-in. tyre and carry a load each of 1,350 lb. They are not supplied with springs or shock absorbers of any description. Each shaft also carries several plungers on which are mounted horse-shoes, each one of which strikes a 75-lb. blow. The wheels are moved across the pavement by a train of gears. The measurement from outside to outside is 19 ft. 8 in., the greatest wheel radius is 10 ft. 10 in., and the least radius of travel of the inside wheel is 8 ft. 7 in. It requires 333 revolutions about the circle to move the wheels across the pavement 2 ft., which is the limit of travel. The foundation of all pavements consists of 8 in. of concrete. The paving is laid on 2 in. of sand, which is packed by a hand pounder until firm and uniform. The concrete sample is 6 in. thick and laid on the foundation. In the first experiment sections of cedar block, granite block, creosote block, and three or four varieties of brick and concrete were tried out. The *Detroit Free Press* reports as follows:—

"In the first experiment with the machine, it was run at a comparatively high

speed to give it a severe test, and the pavement which stood up best under this punishment was the concrete laid under the specifications of the Wayne County Road Commission. The wear on the surface was hardly perceptible, while the same wear on granite block and all brands of brick tried was as great as 1½ in."

MAINTENANCE.

While not belittling the principle of maintaining a road after it is built and following it out in practice, it seems to me, with Wayne County's experience, that it would pay other communities to adopt a form of construction on which it is not necessary to expend from $800 to $1,300 a mile yearly to keep it in fairly usable condition. Our concrete roads are sanitary, as there is no detritus from the road itself; there are few cracks and joints to hold dirt and animal droppings, and there is no dust. The drier the weather, the less dirt on them, as vehicles do not track mud from unimproved cross-roads in dry weather. Our concrete roads have a gritty surface and are not slippery in any kind of weather, affording good traction for all types of vehicles. Horses find good footing on them and automobiles do not skid in wet weather. It is not necessary to build concrete roads with any great amount of crown, and the tendency to drive in one track—so apparent on macadam roads in the formation of ruts—is eliminated, as the driver of a vehicle can sit comfortably in his seat no matter on what part of the road he may be driving; neither can a horse pick out the beaten track, as on a gravel or macadam road, but must be driven or he will zig-zag over the entire road. A crown of ¼ in. to the foot disposes of the surface water and tends to distribute traffic over the entire area of the road. Another desirable feature of concrete roads is smoothness.

CONSTRUCTION NOT DIFFICULT.

With all the other good points in its favour, concrete can be handled with comparative ease, and, providing the work is carried on under skilled supervision, it can be laid with a working force of relatively unskilled labour. It must be borne in mind, however, that the addition of a little cement to a quantity of stone and sand does not make concrete. There is no material which will respond so quickly to a little care, and if proper attention is given to the detail of mixing and curing it will well repay in quality and permanence.

DRAINAGE AND FOUNDATION.

Drainage and good foundation are necessary for any type of road, and on a concrete road the greater care there is taken in this respect the better will be the final result. A well-drained, well-compacted sub-grade will eliminate cracks to a very large extent. Our county is flat, and, although some few sections are sandy, the subsoil is largely of a heavy, sticky clay, therefore not easily drained.

One of the bad features alleged against concrete roads is the tendency to crack. In order to overcome this tendency, we prepare our subgrade as carefully as conditions permit, making it flat and rolling it hard and firm. Owing to temperature changes and the absorption of water, concrete is constantly in motion, and the flat subgrade tends to overcome frictional resistance and thereby prevents longitudinal cracking. On the first concrete road built the subgrade was crowned to conform to the finished crown of the road, and what I term, for the want of a better name, an inverted curb was used. On this road and on the first concrete road built on Michigan Avenue, where practically the whole road is built on a fill, we have developed more cracks than on all subsequent construction. These cracks, however, are well taken care of at a small expense, by the use of a hot, refined tar and sand. On our concrete roads it is the repair of these cracks that has made up surface maintenance cost, and with a well-drained, well-rolled, firm subgrade cracks of all kinds are reduced to a minimum and are not to be seriously considered. We build our roads in 25-ft. sections to provide for contraction and expansion, believing it wise to make our lateral cracks beforehand, so as to properly protect their edges from chipping and spalling. A metal plate, which is a development of previous experiments, is being used. This plate is about $\frac{3}{16}$ in. thick and 3 in. wide, provided with shear members which tie it securely to the concrete base and wearing surface. It is shaped to conform to the crown of the finished road, and two thicknesses of 3-ply asphalted felt (about ¼ in.) are inserted between the two plates at each joint. The use of these plates has practically overcome the wear at the

joints, which are the weakest points in the concrete road, besides securing a smooth, even, continuous finish.

Wayne County is poor in good road material and everything has to be imported. The best results were secured from the use of washed gravel ranging in size from ½ in. to 1½ in. and washed sand from ⅛ in. down. Freedom from loam, clay, or other foreign matter is absolutely insisted upon. We believe in a rich mix, using 1 part of cement to 3 parts of stone, with just a little more than enough sand to fill the voids in the stone. Our roads are constructed with a minimum thickness of 7 in. After our subgrade is prepared we place side rails of lumber 2 in. by 7 in., protected on the top by a 2-in. angle iron. The concrete is laid right on the natural subsoil, which is well sprinkled just previous to placing the concrete to prevent the water in the concrete from being absorbed by capillary attraction. A wet mix is used that has been thoroughly mixed before being placed on the road. No tamping is necessary, although a couple of men are employed to work in it with shovels. It is not wise or desirable to have the mortar and fine aggregate worked to the top, as it is the stone which is to receive the wear. After the concrete is in place no workman is permitted in any way to disturb the finished surface by stepping on it or throwing anything on it. A plank trimmed to the curvature of the road and iron-bound on the edges to give the road its proper shape is used. Two men saw this plank back and forth over the concrete, resting on the side rails or from boards at the sides of the concrete over which this strike-off rides smoothly. It is handled with sufficient care to eliminate the necessity for any considerable floating by the follow-up men. These follow-up men, or floaters, work on a bridge which rests on the form boards or rails at the side of the road, so that there is never any contact with the concrete. The final "smoothing up" is done with wooden floats of home manufacture. When the concrete has become sufficiently firm to permit the removal of the side rails, the finishers, to prevent a sharp division line between the concrete and the gravel shoulders, pare off the outer edges which are formed next to the rails.

Each day's work is finished up to an expansion joint, and not more than twenty minutes is permitted to elapse between batches laid in one day. The work of the day is covered with canvas, and the next day the canvas is removed, and, to prevent the concrete from drying out too rapidly, it is covered to the depth of about 2 in. with any sand or loose soil that may be available. The concrete is sprinkled for eight days and roads are not opened for traffic until at least two weeks after the last concrete is put in place.

Our trunk roads are built 16 ft. wide of concrete, and our secondary roads are built 15 ft. with a minimum width of 24 ft. over all. We have also built concrete roads with the metal 18 ft., 12 ft., and 10 ft. wide. The shoulders are usually built of limestone or gravel in two layers of 3 in. each and rolled with a 10-ton roller. This work is not started until the adjacent concrete is at least three weeks old.

All work is done locally under the day labour plan, and in parts of the busy season as many as 1,200 workmen are employed and from 900 to 1,000 cars of materials a month handled, and we build a mile of road, in the aggregate, every three days. Machinery plays an important part in the work. Gasoline engines furnish the motive power. Concrete is mixed in a mechanical batch mixer, which travels under its own power, and from which a boom projects capable of being swung in a semi-circle. All work is specialised: one crew prepares the grade; another gets the materials on the grade, which is done with such nicety as usually to make it unnecessary to haul in extra sand or pebbles to make a properly proportioned batch; another crew handles the concrete; another builds the shoulders, etc.

System is the keynote of the whole organisation; and when one considers that we are conducting a business enterprise spending $600,000 a year, with 1,000 to 1,200 men employed working simultaneously at points 40 miles apart; that we are handling close upon 1,000 cars of material a month, receiving daily reports, making up payrolls, tracing shipments, keeping crews supplied with materials, and handling a voluminous correspondence; that all these and other details of a big business are handled in the office by four employees, at an expense to the county of $6,225 a year; some idea may be had of the methods employed.

REINFORCED CONCRETE GRAND STAND FOR THE PUBLIC SCHOOL ATHLETIC FIELD, BROOKLYN, NEW YORK.

By HAROLD L. ALT.

The following article on the erection of a reinforced grand stand at Brooklyn, New York, has many features of interest, and should claim the attention of those specially interested in structures of this kind.—ED.

In America, where much of the construction is new and the territory capable of being built over practically unlimited, we find many innovations along architectural lines, and it is not surprising that, although concrete is perhaps the latest practically developed building material, it has already been adopted and utilised in many ways in an expeditious manner which in other countries (more conservative in practice) would be quite unlikely, and perhaps even impossible to attain. It is a considerable novelty, however, even in American construction, to utilise reinforced concrete throughout in the building of grand stands, except in perhaps a few of most recent construction. Even in these structural steel is generally used as a framework, with either a concrete or a wood flooring supported on the steel skeleton.

A notable exception to this prevailing custom, nevertheless, is presented in the reinforced concrete grand stand which is nearing completion in the Borough of Brooklyn, City of New York, U.S.A.

This stand is being built by the New York Board of Education on its athletic field, for the school children, which is maintained at the above site. The structure itself is being erected from designs laid out by Mr. C. B. J. Snyder, Architect and School Superintendent, who has complete charge of all the school buildings and other construction work carried out under the auspices of the Board of Education in the entire city. As far as the design itself is concerned, aside from the reinforcing details, which will be taken up later, there are several unusual features incorporated.

Probably the novelty of greatest interest and of the most radical nature consists of concaving the front of the stand in such a manner as to render the entire track visible to those in the front rows without making it necessary to rise during the approach or recession of the contestants moving along the track in front of the stand. The concaving of the face of this stand is made just sufficient to eliminate this objectionable feature, as the track can be sighted through the hollow of the curve which in a straight stand would be obstructed by the front railing.

The second notable feature consists of the removal of the superfluous hanger-on to a point where he is at least out of the way, if not eliminated. This is effected by depressing the standing room or area in front of the stand and along the side of the track a distance of some 4 ft. and 6 in. below the

level of the track itself. This brings the heads and shoulders of those congregating along the edge of the track just a little above the track level, and permits of their assembling in this depressed area at any point in front of the grand stand without cutting off the view of the stand spectators except for about 18 in. above the ground, to which height the heads and shoulders project. This feature is graphically shown in *Fig.* 1, which is a typical cross section of the stand.

Careful thought is also demonstrated in the arrangement of the judges' stand, which places the judges on three steps of different heights, so that their

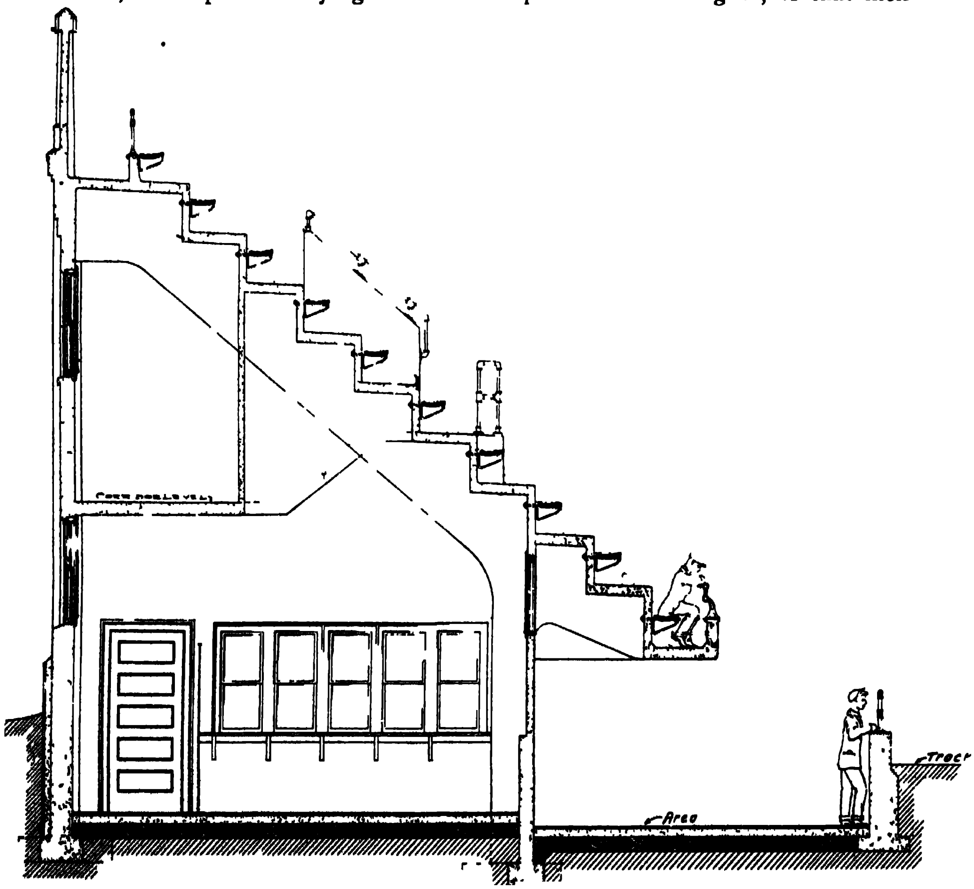


Fig. 1. Typical Cross Section of Stand
REINFORCED CONCRETE GRAND STAND, BROOKLYN, N Y

angle of vision rises *vertically* from the finish line, and not (as is usually the case) in a line parallel to the track.

The athletic track itself is enclosed on both sides with concrete curbing, in which brass markers are located by surveyors for a finish line and proper starting points for distances of 120, 220, 440, and 880 yards and one mile.

Below the stand the space is utilised principally for two locker and dressing-rooms, a check-room, and two toilet-rooms having been arranged as shown in

the plan, *Fig.* 2, with the check-room in the centre and one dressing-room and toilet-room on either side.

Fig. 5 shows the south half of the floor plan of the top of the structure (grand stand floor). A front elevation of the south half as the stand will appear when finished is shown in *Fig.* 3 and the rear elevation in *Fig.* 4.

In regard to the concrete construction there were problems met with which are not to a great extent encountered in ordinary work. The compound cross-beam, shown in *Fig.* 6, which was originally designed as a simple beam with an overhung cantilever end, it was decided later to support on the overhang by small iron posts. This was not because the beam itself is not strong enough to carry any reasonably supposed load, but in a structure of this kind unforeseen contingencies must be provided for.

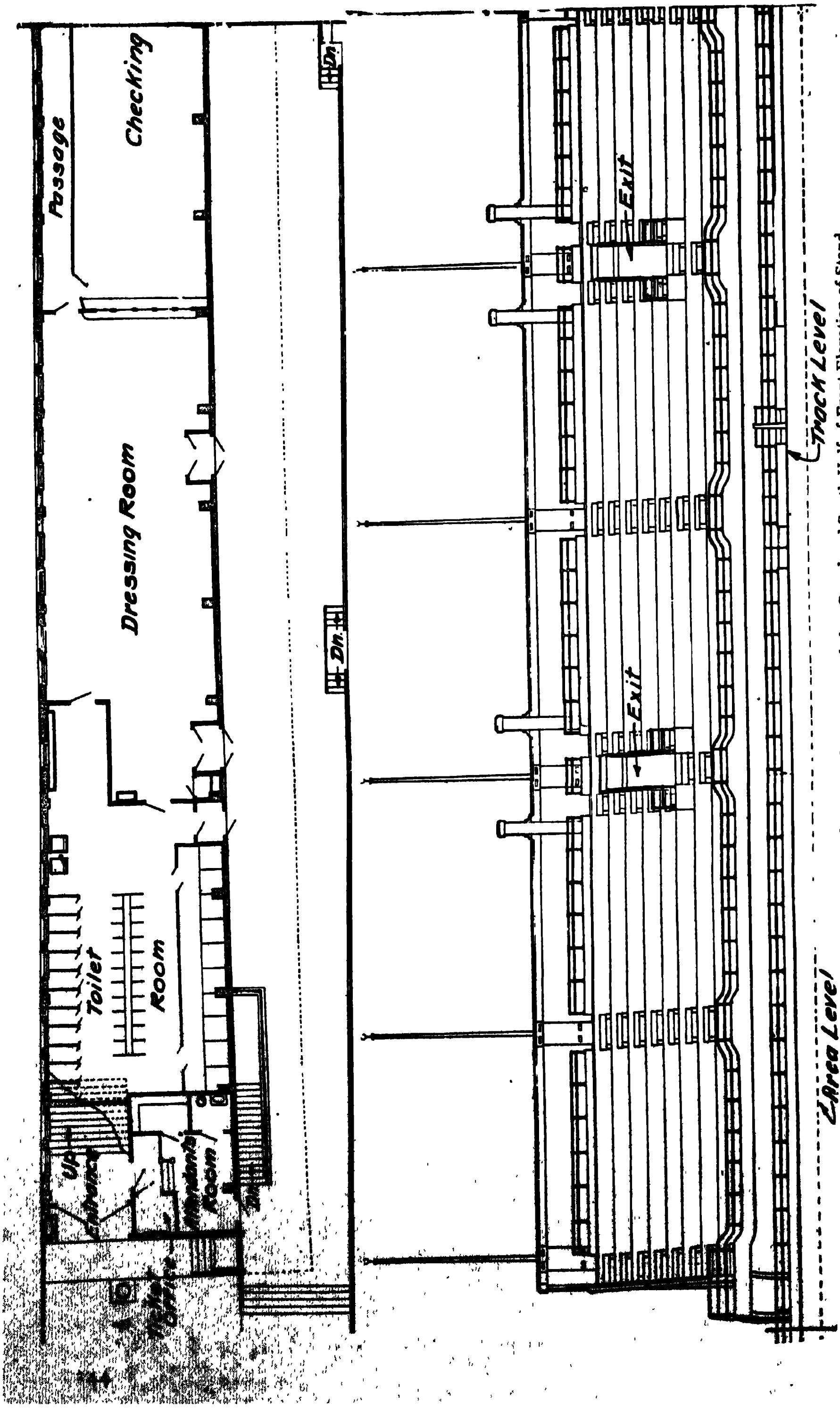
The walls of the building (with the exception of those of the boiler and coal room), the partitions, piers, girders, floor, stairs and gallery front are all of reinforced concrete. The walls of the boiler and coal room, the retaining wall in front of the stand, and the concrete curbing around the track are of monolithic construction without reinforcing. The partition separating the connecting passage from the checking room is made up of panels of No. 8 wire, of 1½ in. mesh, which is set in ⅞-in. channel iron frames and supported with wrought iron pipe posts with flanged caps and bases, secured to the floor with expansion bolts.

The forms used in this work were built in general of ⅞-in. matched and planed material, with the stiffeners of 2 in. by 3 in., 3 in. by 4 in., 3 in. by 6 in., and 3 in. by 8 in. in size, being spaced respectively 16 in., 18 in., 20 in. and 24 in. on centres, this being determined by the various spans of slab and thickness of concrete supported. The forms were driven tightly together to prevent leakage, and braced and supported in a most careful manner to insure smooth faces and absolutely true lines to the work. It is easy to see that great stiffness was required in this part of the work, as the specifications limited the variation from the figured sizes given on the plans to not more than ⅛ in. These forms were maintained a proper distance apart by wooden spreaders, which were later replaced with 2 in. by 2 in. concrete struts, of a length exactly equal to the thickness of the wall. These struts were placed as often as required and the concrete poured in around them, thus casting the struts into the wall permanently.

The composition of the concrete used in the construction of the stand for all the piers, walls, and the retaining wall in front of the structure, together with the floor or roof slab, and the curbs about the running track, is composed of a mixture of one part Portland cement, two parts clean, sharp, medium coarse sand, and four parts of ¾-in. and ⅝-in. stone. The ¾-in. stone is used for the vertical construction, and the ⅝-in. in the grand stand floor.

The cement used was tested as follows :—

After 24 hours' exposure in air when mixed neat, it had to stand a tensile stress of 200 lb. per sq. in. without rupture; and after 24 hours in air and six days in water it was required to resist 500 lb. per sq. in. Further, it was required to show an increased strength at the end of 28 days over whatever the tensile strength developed at the end of the first six. Practically all the concrete used was mixed dry in a batch mixer until the dry materials were thoroughly and evenly mixed (great attention being paid to this portion of the work), after



Figs. 2 and 3. Showing South Half of Plan of Apartments below Stand and South Half of Front Elevation of Stand.
Reinforced Concrete Grand Stand, Brooklyn, N.Y.

which water was added and the mixing continued again until the batch was of an absolutely uniform character and colour throughout, and until the mortar was evenly distributed through the mass of stone. This unset concrete was not allowed to stand, but was immediately deposited as soon as the mixing was completed, any excess that was left for a period of longer than two hours not being allowed to be used or even retempered.

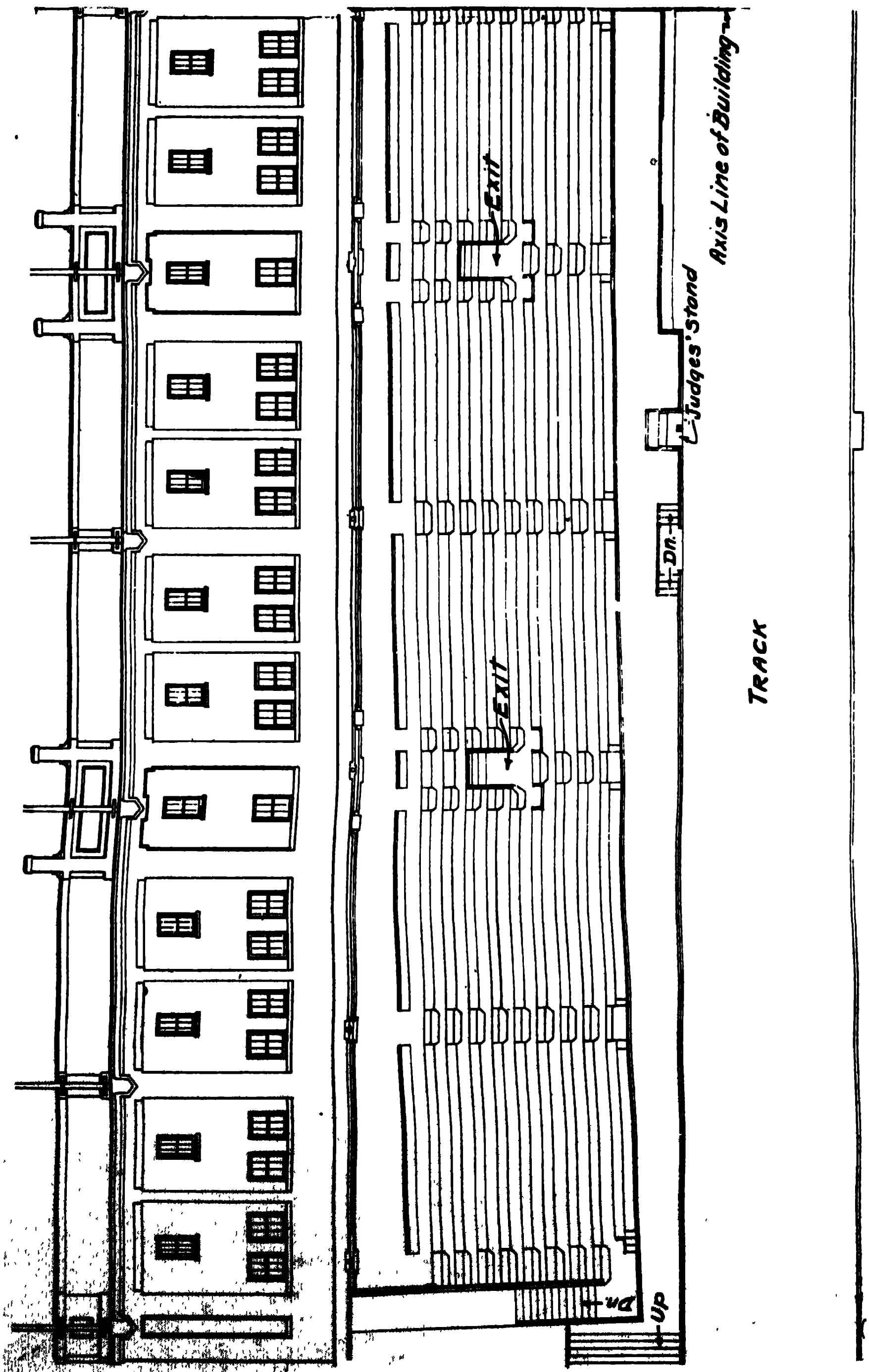
In placing the concrete in the forms it was used at a consistency so that it would quake in the wheelbarrows but not so thin as to allow the stones to settle to the bottom. In the heavy walls it was puddled into position with a puddling bar, but in the thin 4-in. walls it was settled into place with the assistance of hammering on either side of the forms while the mixture was being deposited. The concrete was handled mainly by means of inclined runways, up which it was wheeled in barrows, the incline of the stand making this means peculiarly suitable. In casting the high columns in the back a hoist was used (since these were poured first), and the concrete was raised by the bucketful with a rope run through a single sheave, which was attached to a cross piece temporarily suspended from the form work for the columns.

After placing the concrete the top surfaces were protected from the sun with a covering and were amply sprayed, especially during the *first* 24 hours.

The reinforcing was, in general, of rods, with the exception of the wire mesh used in the grand stand floor. This wire reinforcement is of 4-in. mesh, with No. 6 longitudinal wires and No. 12 ½-in. diagonal tension wires, being made by the American Steel and Wire Co. The reinforcing rods were furnished by the Corrugated Bar Co., of Buffalo, N.Y. *Fig.* 6 shows the method of reinforcement at the stairways.

In the beginning of the work experiments were made with various compounds, with the idea of producing a smooth finished surface on the concrete and to prevent sticking. Among these might be mentioned crude oil, soap, oil paper, etc., all of which did much toward helping out the sticking part, but very little toward eliminating the lumber marks of the form boards. Finally the inside of all the forms was covered with galvanised sheet iron, and this method was followed throughout. After the foundations were poured, the piers were built up separately to the lower side of the cross girders, being allowed to stand thus for 24 hours before the curtain walls, girders, and the top of the grand stand were started. The girders were notched and halved together, and where the curtain walls, panels, etc., were to be cast later, short iron rod dowel pins were used, which were thoroughly greased and cast into both sections of the concrete. Although the pouring of the skeleton and the walls of each section, extending from the foundation to the underside of the girders, was stopped temporarily during the night, no longer period of suspension was permitted; and even when thus stopped the concrete was brought up to and finished against a metal strip, so as to leave a sharp, even, and fine hair joint when the additional concrete was poured. Upon resuming work after a suspension of this kind the surface of the previous construction was roughened up, then thoroughly cleaned and wet down, after which it was flushed off with a cement mortar composed of one part of Portland cement and two parts sand, whereupon the work was immediately continued.

The grand stand floor was built in panels reaching from girder to girder



Figs. 4 and 5. Showing South Half of Rear Elevation of Stand and Floor Plans of Top of Structure.
REINFORCED CONCRETE GRAND STAND, BROOKLYN, N.Y.

and extending half-way across. The rods which were used as connection dowels here were also greased, and the panels were extended from the front of the stand to the rear and sideways from girder to girder until completion, without ceasing the work during this time. The back columns and pilasters were built separately and the panels between were filled in later. The expansion joints, consisting of two vertical joints, formed the entire length of the stand, together with ten joints in the floor slab over the girders and spaced about 24 ft. apart. All of these joints were filled with mineral wax and oakum.

All necessary small holes required to be placed in the concrete were formed

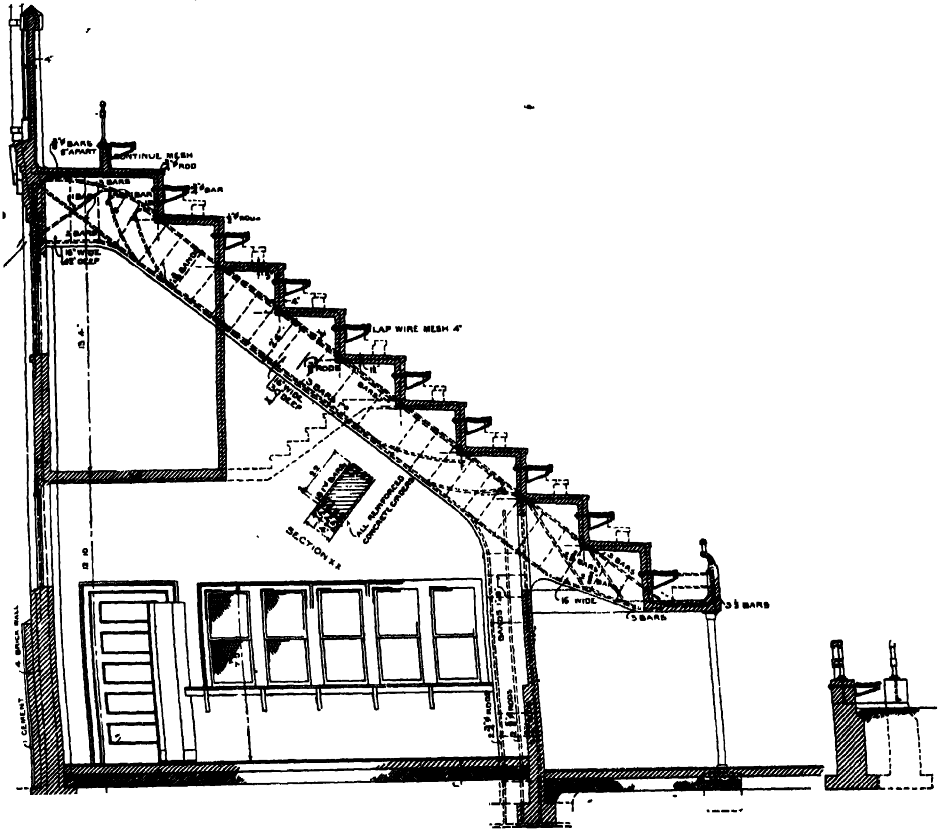
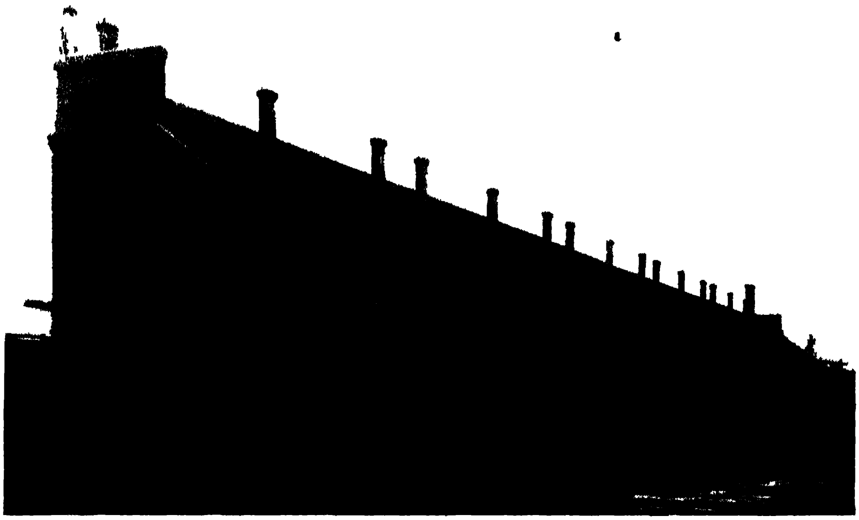


Fig. 6. Cross Section showing Construction and Reinforcement.
Reinforced Concrete Grand Stand, Brooklyn, N.Y.

with tapered wooden plugs, which were dipped in paraffin so as to make them impervious to water and to assist in their removal. The railing supports consist of round bar anchors threaded and provided with nuts and locknuts, which were cast in the concrete at the points required. The seats are supported on 2 in. by ½ in. wrought iron brackets, which are clearly shown in structural position in the photographs, and the seats themselves are formed by wooden strips laid along these brackets and fastened thereto.

The brackets have the lower arm resting on a short cross piece of angle iron which takes the weight of the seat, while the upper end is extended through

the riser of the step with a washer and a nut placed on the inside. After the placing of these brackets all the holes were filled up with a 1-2 cement mortar



Figs. 7 and 8. Showing Front and Rear of Stand.
Reinforced Concrete Grand Stand, Brooklyn, N. Y.

mixture, during which operation the surrounding surfaces were kept well wet. The top dressing of the passage and entire grand stand floor, including the risers

of the steps, is composed of 1-in. finishing coat mixed from one part Portland cement, one part sand, and one part grit; this was put down at one and the same time with the rest of the floor and was floated to a true and smooth finish. As soon as the forms could be pulled, and before the initial set had taken place, the entire outer surface was trowelled to a polish and all the corners and edges were rounded off.

The outside of all the walls and piers was floated down with a wooden float and the imperfections removed. The window frames were set in a good bed of roofers' cement. The outside walls were given a coat of white lead and Rockaway Beach seashore sand, and the inside walls and ceiling were rubbed down with a wire brush ready for painting.

The pavements laid in the area in front of the grand stand are built up as follows :—First a 7-in. bed of clean steam cinders was put down, over which was

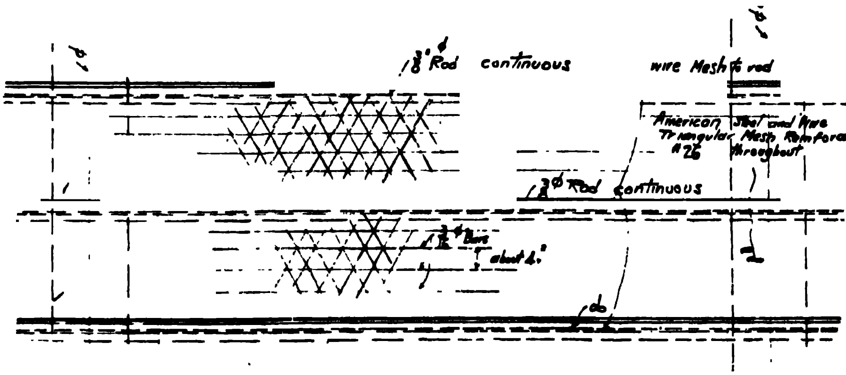
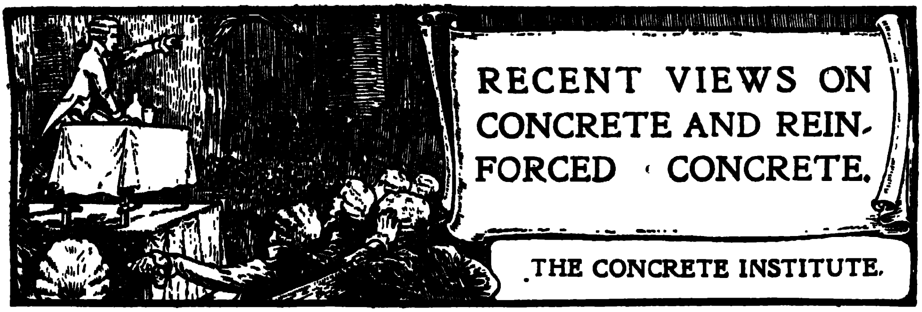


Fig. 9. Plan of Step Reinforcement.
REINFORCED CONCRETE GRAND STAND, BROOKLYN, N.Y.

spread 4 in. of broken stone concrete, and over the top of this a 1-in. coat of dressing, which was carefully trowelled, then roughened with a toothed wheel and marked off into squares. The concrete used on this part of the work consisted of a mixture of one part Portland cement, two parts sand, and five parts of broken stone which will pass through a $1\frac{1}{2}$-in. ring; the top dressing is composed of a very rich mixture, namely, one part of Portland cement to one part of sand.

The running track is made up of the following :—

A filling is first deposited (consisting of broken stone that will pass through a 2-in. screen), which is placed on top of a well-tamped bed of earth; the broken stone layer running from 3 in. to 6 in. thick and covered with 3 in. of clean rolled steam cinders, and then 3 in. more of $\frac{1}{4}$-in. screen cinders mixed with clay in the proportion of two parts of cinders to three parts of clay. This entire mass was then rolled with a steam roller to a hard and even surface and well sprinkled.



It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.
The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

ECONOMY IN REINFORCED CONCRETE DESIGN.

MR. JOHN A. DAVENPORT, M.Sc. (Vict.), B.Eng. (Liverpool), Assoc.M.Inst.C.E., A.M.I.Mech.E., M.C.I.

The following is an abstract of a Paper read at the 33rd Ordinary General Meeting of the Institute. The various Tables comprised in the Paper are only given here in summarised form. A short summary of the discussion is also given.

PART I.

Introduction.

THE question of economy in reinforced concrete design may be discussed with regard to: (1) The engineering structure; (2) the architectural structure.

In order to design economical reinforced concrete structures many factors have to be considered, some of which vary in all cases, but there are three fundamental points which influence all structures in the same way, and these are: (1) The effect of beam section on economy; (2) the effect of percentage steel on economy; (3) the effect of layout or arrangement of beams, columns, etc., on economy.

TABLE I.
Cost of Beams 10 *ft. long, of Moment of Resistance* = 500,000 *lb.-in. for Various Ratios of* $\frac{d+1}{b}$.

Per cent. Steel.	$\frac{d+1}{b}$	Total Cost in Shillings of Beams 10 ft. long.
1·0 S.S.* ...	3	37·54
,, ...	2½	38·76
,, ...	2	40·82
,, ...	1½	43·57
,, ...	1	48·48
1·0 D.S. ...	3	37·02
,, ...	2½	38·34
,, ...	2	40·45
,, ...	1½	43·59
,, ...	1	48·91
T beams with 3-in. slab	3	22·99
	2½	23·61
	2	24·62
	1½	26·43
	1	29·21

* S.S. means single reinforcement.
D.S. means double reinforcement.

The total cost of any reinforced concrete structure, whether a single slab, column, a whole floor, or a complete frame, will be the sum of the total costs of the three items: Concrete, steel, and centering, and these, in their turn, will depend upon the unit costs. Now these unit costs will vary for different parts of the one complex structure, but not for any single member; so that while a mathematical expression for a single member is possible it would be impossible, owing to the very large number of variable quantities involved, to deduce a mathematical general expression for all classes of structure, simple and complex.

The following unit costs are taken throughout:—

Concrete in beams and columns...	40s. per cu. yd.
Concrete in slabs (per in. of depth)	1s. per sup. yd.
Centering to beams and columns	2s. per sup. yd.

Centering to slabs ... ... 1s. 6d. per sup. yd.
Steel in column laterals (bent and fixed) £17 per ton.
Steel, main reinforcement (bent and fixed) ... ... £10 per ton.

TABLE II.

Cost of Beams 10 ft. long, of Moments of Resistance = 1,000,000, 2,000,000, and 4,000,000 lb.-in. for Various Ratios of $\frac{d+1}{b}$.

Per cent. Steel.	R in lb.-in.	$\frac{d+1}{b}$	Total Cost in Shillings of Beams 10 ft. long.
1·0 S.S. ...	1,000,000	3	56·39
,, ...	1,000,000	2½	58·19
,, ...	1,000,000	2	61·58
,, ...	1,000,000	1½	66·05
,, ...	1,000,000	1	73·58
,, ...	2,000,000	3	84·92
,, ...	2,000,000	2½	88·30
,, ...	2,000,000	2	93·73
,, ...	2,000,000	1½	101·06
,, ...	2,000,000	1	113·60
,, ...	4,000,000	3	128·76
,, ...	4,000,000	2½	134·30
,, ...	4,000,000	2	143·18
,, ...	4,000,000	1½	154·76
,, ...	4,000,000	1	174·70
1·0 D.S. ...	1,000,000	3	55·64
,, ...	1,000,000	2½	57·84
,, ...	1,000,000	2	61·30
,, ...	1,000,000	1½	66·38
,, ...	1,000,000	1	74·85
,, ...	2,000,000	3	84·49
,, ...	2,000,000	2½	88·10
,, ...	2,000,000	2	93·71
,, ...	2,000,000	1½	101·99
,, ...	2,000,000	1	115·42
,, ...	4,000,000	3	128·56
,, ...	4,000,000	2½	134·40
,, ...	4,000,000	2	143·44
,, ...	4,000,000	1½	156·70
,, ...	4,000,000	1	178·00
T beams with 4-in. slabs	1,000,000	3	33·61
	1,000,000	2½	34·48
	1,000,000	2	36·16
	1,000,000	1½	39·22
	1,000,000	1	44·41
T beams with 6-in. slabs	2,000,000	3	49·32
	2,000,000	2½	51·41
	2,000,000	2	55·03
	2,000,000	1½	58·79
	2,000,000	1	67·68
T beams with 8-in. slabs	4,000,000	3	74·35
	4,000,000	2½	78·27
	4,000,000	2	83·17
	4,000,000	1½	91·04
*	4,000,000	1	97·76

* This section (23 in. by 19 in.) has not the same ratio of $\frac{d+1}{b}$, because any smaller depth with an 8-in. slab would have the neutral axis in the slab. It is therefore taken as the shallowest possible T-beam section, and not because $\frac{d+1}{b}=1$.

The stresses used in calculating sizes are :—

Compressive stress in concrete (columns and beams) ...	600 lb. per sq. in.
Tensile stress in steel	16,000 lb. per sq. in.
Compressive stress in steel (maximum in columns)	16,000 lb. per sq. in.

PART II.

The Economical Beam Section.

To determine the economical beam section it will be necessary to consider various ratios of depth to breadth, and various percentages, both of single and double reinforcement. The effect of varying the ratio of depth to breadth is first dealt with for a fixed percentage tension reinforcement, and a definite moment of resistance. The effect of variation of percentage reinforcement and moment of resistance are then considered, after having determined the most economical ratio of depth to breadth. The tension reinforcement is firstly taken as 1·0 per cent. for all plain sections, the doubly-reinforced beams having various percentages of compression steel, and the moment of resistance is 500,000 lbs.

Notes on Table I.

An inspection of Tables I. and II. reveals several important facts relating to the economy of beams, and these are :—

1. For similar loadings, a correctly designed T-beam section is much more economical than any other.

2. For similar loadings, doubly-reinforced plain beams, with the same area of steel top and bottom, are more economical than singly-reinforced plain beams when the ratio of total depth to breadth is 2 or more; but they are less economical than singly-reinforced beams when the ratio of depth to breadth is less than 2.

3. For all types of section a ratio of depth to breadth of 3 is more economical than any smaller ratio.

Effect of Varying Percentage Reinforcement on Economy in Plain Beams.

The cost of plain beams with various percentages of single and double reinforcement are calculated by the expressions already stated, and given in Table III., for a moment of resistance of 500,000 lb.-in. Single reinforcement from 0·6 to 1·6 and double reinforcement from 0·5 to 3 per cent., are taken.

The important conclusions revealed by the table are—

1. For plain beams the most economical single reinforcement percentage is from 1 to 1·2.
2. For plain beams the most economical double reinforcement percentage is 1, with equal tension and compression steel.

TABLE III.

Effect of Varying Percentage on Cost of Beams 10 ft. long for B = 500,000 *lb.-in. and* $\frac{d+1}{b} = 3$.

Per cent. Steel.		k.	Total Cost in Shillings of Beams 10 ft. long.
0·6 S.S.	...	—	37·51
0·8 S S.	...	—	37·73
1·0 S.S.	...	—	37·54
1·2 S.S.	...	—	37·45
1·4 S.S.	...	—	37·79
1·6 S.S.	...	—	37·82
0·5 D.S.	...	1	38·66
,,	...	$\frac{3}{4}$	38·81
,,	...	$\frac{1}{2}$	38·78
,,	...	$\frac{1}{4}$	39·10
1·0 D.S.	...	1	37·02
,,	...	$\frac{3}{4}$	37·15
,,	...	$\frac{1}{2}$	37·32
,,	...	$\frac{1}{4}$	37·39
2·0 D.S.	...	1	38·07
,,	...	$\frac{3}{4}$	38·24
,,	...	$\frac{1}{2}$	38·07
,,	...	$\frac{1}{4}$	38·74
3·0 D.S.	...	1	39·74
,,	...	$\frac{3}{4}$	40·22
,,	...	$\frac{1}{2}$	40·58
,,	...	$\frac{1}{4}$	41·39

TABLE IV.

Ratio of Total Load to Total Cost for Columns with 1 per cent. Main Steel and Different Hoopings.

Size of Core. b in.	Diameter of Hooping. d in.	p'.	$\frac{\text{Total Cost}}{\text{P}}$
10 × 10	$\frac{3}{16}$	0·2b	0·889
10 × 10	$\frac{3}{16}$	0·3b	—
10 × 10	$\frac{1}{4}$	0·2b	0·891
10 × 10	$\frac{1}{4}$	0·3b	0·917
10 × 10	$\frac{1}{4}$	0·4b	0·921
10 × 10	$\frac{5}{16}$	0·2b	0·911
10 × 10	$\frac{5}{16}$	0·3b	0·932
10 × 10	$\frac{5}{16}$	0·4b	0·946
10 × 10	$\frac{5}{16}$	0·5b	0·957
10 × 10	$\frac{5}{16}$	0·6b	0·946
10 × 10	$\frac{3}{8}$	0·2b	0·921
10 × 10	$\frac{3}{8}$	0·3b	0·954
10 × 10	$\frac{3}{8}$	0·4b	0·975
10 × 10	$\frac{3}{8}$	0·5b	0·991
10 × 10	$\frac{3}{8}$	0·6b	0·985
6 × 6	$\frac{3}{16}$	0·2b	1·202
6 × 6	$\frac{3}{16}$	0·3b	1·252
6 × 6	$\frac{3}{16}$	0·4b	1·287
6 × 6	$\frac{3}{16}$	0·5b	1·307
6 × 6	$\frac{3}{16}$	0·6b	1·325
6 × 6	$\frac{1}{4}$	0·2b	1·285
6 × 6	$\frac{1}{4}$	0·3b	1·328
6 × 6	$\frac{1}{4}$	0·4b	1·358
6 × 6	$\frac{1}{4}$	0·5b	1·378
6 × 6	$\frac{1}{4}$	0·6b	1·392

Economy in Reinforced Concrete Beam Construction.

(*a*) Reinforced concrete T-beams, correctly designed, with the total depth three times the breadth of web, are more economical than any other section, for all values of unit cost and loading.

(*b*) For plain beams, reinforced in any way whatever, the most economical ratio of depth to breadth is 3, for all values of unit cost and loading.

(*c*) For singly-reinforced plain beams, the most economical reinforcement percentage runs from 1 to 1·2, for all values of unit cost and loading.

(*d*) For doubly-reinforced plain beams, the most economical reinforcement percentage is 1, with equal tension and compression steel, for all values of unit cost and loading.

(*e*) Plain beams doubly-reinforced may be more economical than similar beams singly-reinforced, the relative economies depending upon the values of unit cost and ratio of depth to breadth of section, but not to any appreciable extent upon the loading.

The foregoing conclusions are quite independent of any economies effected by adopting uniform sections throughout a design.

PART III.

The Economical Column Section.

Square columns only will be considered in this part because they are oftener used in reinforced concrete frame construction than any other section.

The relative values of cost per ton of load will be practically the same for percentages of main reinforcement other than 1, so that Table IV. shows that the effect of variations in lateral reinforcement is—

1. For a fixed diameter of lateral the greatest economy of space occurs when the laterals are closest.
2. For a fixed spacing of laterals the greatest economy of space occurs when the diameter of lateral is largest.
3. For a fixed diameter of lateral the greatest economy of cost occurs when the spacing is closest.
4. For a fixed spacing of laterals the greatest economy of cost occurs when the diameter of lateral is least.
5. For a fixed spacing and diameter of laterals, the cost of the laterals is the same for all sizes of columns.

The results of Tables IV. and V. may now be summarised as follows :—

Economy in Reinforced Concrete (Square) Column Construction.

(*f*) For ordinary values of unit cost, square columns, helically reinforced, are most economical of cost when the diameter of lateral is small, the pitch of lateral is 0·2 the breadth of core, and the percentage longitudinal steel is high.

TABLE V.

Effect of Varying Percentage Longitudinal Reinforcement on Cost.

Size of Core. b in.	Diameter of Hooping. d in.	p'.	Total Cost P
10 × 10	$\frac{3}{16}$	0·2b	0·893
10 × 10	$\frac{3}{16}$	0·2b	0·889
10 × 10	$\frac{3}{16}$	0·2b	0·873
10 × 10	$\frac{3}{16}$	0·2b	0·861
10 × 10	$\frac{3}{16}$	0·2b	0·851
10 × 10	$\frac{3}{16}$	0·2b	0·842
10 × 10	$\frac{3}{16}$	0·2b	0·834
6 × 6	$\frac{3}{16}$	0·2b	1·216
6 × 6	$\frac{3}{16}$	0·2b	1·202
6 × 6	$\frac{3}{16}$	0·2b	1·139
6 × 6	$\frac{3}{16}$	0·2b	1·091
6 × 6	$\frac{3}{16}$	0·2b	1·052
6 × 6	$\frac{3}{16}$	0·2b	1·018

(*g*) Increased economy of cost will result from the use of longitudinal reinforcement having a lower yield point than ordinary mild steel, provided such material be cheaper than mild steel.

(*h*) The greatest economy of space is obtained by using large diameter laterals, pitched at 0·2 the breadth of core, and a high percentage of longitudinal reinforcement.

PART IV.

Economy in Slab, Beam, and Column Construction.

A floor of breadth 20 ft. and length varying with the slab spans, as will be more clearly seen later, is taken. This is divided into ten bays, supported by nine beams 20 ft. long between the walls, and by the walls all round the outside edge. The beams are taken as supported at three points by the addition of a row of columns running down the middle of the floor.

Superloads of from ½ to 4 cwt., advancing by ½ cwt., and slabs of from 1 in. to 8 in. total thickness, advancing by ½ in., are taken. The slabs are designed as continuous slabs, with the four different percentages 0·6, 0·8, 1·0, 1·2 single reinforcement, as it is expected that the most economical percentage will be included in this range.

TABLE VI.

Slab with 0·6 per cent. Single Reinforcement and ½-in. Cover.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	2·60
1½	3·20
2	3·80
2½	4·39
3	4·99
3½	5·59
4	6·19
4½	6·79
5	7·39
5½	7·98
6	8·58
6½	9·18
7	9·78
7½	10·38
8	10·98

TABLE VII.

Slab with 0·8 per cent. Single Reinforcement and ½-in. Cover.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	2·63
1½	3·26
2	3·89
2½	4·53
3	5·16
3½	5·79
4	6·42
4½	7·05
5	7·68
5½	8·31
6	8·94
6½	9·57
7	10·21
7½	10·84
8	11·47

TABLE VIII.

Slab with 1·0 per cent. Single Reinforcement and ½-in. Cover.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	2·66
1½	3·33
2	3·99
2½	4·66
3	5·32
3½	5·98
4	6·65
4½	7·31
5	7·98
5½	8·64
6	9·30
6½	9·97
7	10·63
7½	11·30
8	11·96

TABLE IX.

Slab with 1·2 per cent. Single Reinforcement and ½-in. Cover.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	2·70
1½	3·39
2	4·09
2½	4·79
3	5·48
3½	6·18
4	6·88
4½	7·57
5	8·27
5½	8·97
6	9·67
6½	10·36
7	11·06
7½	11·76
8	12·45

The cost of slabs alone is taken first, and then the combinations of slabs, beams, and columns are afterwards considered.

Economy in Plain Reinforced Concrete Slabs.

The costs of plain slabs are given in Tables VI., VII., VIII., and IX., corresponding to 0·6, 0·8, 1·0, 1·2 per cent. single reinforcement. For every thickness of slab from 1 in. to 8 in., advancing by ½ in., the slab span is calculated for the superloads 1, 1½, 2, 2½, 3, 3½, 4 cwt. per sq. ft., this figure being necessary to get the length of floor and then the area of floor.

Economy in Slab and Beam Construction.

Here we have T-beams of 20 ft. span, supporting slabs of various thicknesses and reinforced with various percentages of steel, the cost being worked out per super yard, under the head of beams and slab, and the total cost obtained by addition. It is not

Table X.

Cost per Sup. Yd. of Beam and Slab Floors to carry 1 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 0·6 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	8·7
1½	7·4
2	7·2
2½	7·4
3	7·7
3½	8·1
4	8·6
4½	9·1
5	9·6
5½	10·1
6	10·7
6½	11·3
7	11·8
7½	12·4
8	13·0

Table XI.

Cost per Sup. Yd. of Beam and Slab Floors to carry 1 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 0·8 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	8·7
1½	7·5
2	7·3
2½	7·5
3	7·9
3½	8·3
4	8·8
4½	9·3
5	9·9
5½	10·4
6	11·0
6½	11·6
7	12·2
7½	12·8
8	13·5

Table XII.

Cost per Sup. Yd. of Beam and Slab Floors to carry 1 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 1·0 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	8·7
1½	7·5
2	7·4
2½	7·6
3	8·0
3½	8·5
4	9·0
4½	9·5
5	10·2
5½	10·7
6	11·4
6½	12·0
7	12·6
7½	13·3
8	13·9

Table XIII.

Cost per Sup. Yd. of Beam and Slab Floors to carry 1 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 1·2 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd
1	8·6
1½	7·5
2	7·4
2½	7·7
3	8·1
3½	8·6
4	9·2
4½	9·8
5	10·4
5½	11·1
6	11·7
6½	12·4
7	13·0
7½	13·7
8	14·4

Table Xa.

Cost per Sup. Yd. of Beam and Slab Floors to carry 2 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 0·6 per cent. Single Reinforcement.

Thickness of Slab Ins.	Total Cost in Shillings per sup. yd.
1	13·03
1½	10·19
2	9·48
2½	9·25
3	9·29
3½	9·52
4	9·85
4½	10·27
5	10·68
5½	11·19
6	11·68
6½	12·19
7	12·72
7½	13·25
8	13·78

Table XIa.

Cost per Sup. Yd. of Beam and Slab Floors to carry 2 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 0·8 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	13·04
1½	10·27
2	9·50
2½	9·32
3	9·45
3½	9·70
4	10·05
4½	10·50
5	10·97
5½	11·48
6	12·00
6½	12·55
7	13·12
7½	13·64
	14·26

Table XIIa.

Cost per Sup. Yd. of Beam and Slab Floors to carry 2 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 1·0 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	13·02
1½	10·29
2	9·58
2½	9·39
3	9·56
3½	9·85
4	10·26
4½	10·73
5	11·24
5½	11·77
6	12·35
6½	12·92
7	13·51
7½	14·09
	14·71

Table XIIIa.

Cost per Sup. Yd. of Beam and Slab Floors to carry 2 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 1·2 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	12·94
1½	10·27
2	9·60
2½	9·51
3	9·66
3½	10·02
4	10·45
4½	10·96
5	11·50
5½	12·07
6	12·65
6½	13·26
7	13·89
7½	14·54
8	15·17

proposed to deal with all the super loads already given, but to deal completely with 1 cwt., 2 cwt., 3 cwt., and 4 cwt. per sq. ft.

Table Xb.

Cost per Sup. Yd. of Beam and Slab Floors to carry 3 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 0·6 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	17·2
1½	13·0
2	11·5
2½	11·0
3	10·8
3½	10·9
4	11·1
4½	11·4
5	11·8
5½	12·2
6	12·6
6½	13·1
7	13·6
7½	14·4
8	14·7

Table XIb.

Cost per Sup. Yd. of Beam and Slab Floors to carry 3 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 0·8 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
	17·2
1½	13·0
2	11·5
2½	11·0
3	10·9
3½	11·0
4	11·3
4½	11·6
5	12·1
5½	12·5
6	13·0
6½	13·5
7	14·0
7½	14·5
8	15·1

Table XIIb.

Cost per Sup. Yd. of Beam and Slab Floors to carry 3 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 1·0 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	17·1
1½	12·9
2	11·6
2½	11·1
3	11·0
3½	11·2
4	11·5
4½	11·8
5	12·3
5½	12·8
6	13·3
6½	13·8
7	14·3
7½	14·9
8	15·6

Table XIIIb.

Cost per Sup. Yd. of Beam and Slab Floors to carry 3 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 1·2 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
	16·8
1½	12·9
2	11·6
2½	11·2
3	11·1
3½	11·3
4	11·7
4½	12·0
5	12·5
5½	13·1
6	13·6
6½	14·2
7	14·8
7½	15·3
8	16·0

Table Xc.

Cost per Sup. Yd. of Beam and Slab Floors to carry 4 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 0·6 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	21·2
1½	15·6
2	13·5
2½	12·7
3	12·3
3½	12·1
4	12·2
4½	12·5
5	12·8
5½	13·1
6	13·5
6½	14·0
7	14·4
7½	14·9
8	15·3

Table XIc.

Cost per Sup. Yd. of Beam and Slab Floors to carry 4 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 0·8 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	21·0
1½	15·5
2	13·5
2½	12·7
3	12·3
3½	12·3
4	12·4
4½	12·7
5	13·0
5½	13·4
6	13·8
6½	14·3
7	14·8
7½	15·3
8	15·8

Table XIIc.

Cost per Sup. Yd. of Beam and Slab Floors to carry 4 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slab with 1 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	20·8
1½	15·5
2	13·5
2½	12·7
3	12·5
3½	12·4
4	12·6
4½	12·9
5	13·3
5½	13·7
6	14·1
6½	14·6
7	15·1
7½	15·7
8	16·2

Table XIIIc.

Cost per Sup. Yd. of Beam and Slab Floors to carry 4 cwt. per Sq. Ft. Superload. Non-continuous T beams of 20 ft. Span and Slabs with 1·2 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	20·8
1½	15·4
2	13·5
2½	12·8
3	12·6
3½	12·6
4	12·8
4½	13·1
5	13·5
5½	14·0
6	14·5
6½	15·0
7	15·5
7½	16·1
8	16·7

The calculated results are given in summarised form in Tables X, XA, XB, XC, to XIII., XIIIA, XIIIB, and XIIIc.

TABLE XIV.

Cost of Slab, Beam, and Column Construction to carry 1 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 0·6 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	7·1
1½	6·0
2	6·0
2½	6·4
3	6·8
3½	7·3
4	7·8
4½	8·4
5	8·9
5½	9·4
6	10·0
6½	10·5
7	11·1
7½	11·7
8	12·3

TABLE XV.

Cost of Slab, Beam, and Column Construction to carry 1 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 0·8 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	7·1
1½	6·0
2	6·1
2½	6·5
3	7·0
3½	7·5
4	8·1
4½	8·6
5	9·2
5½	9·7
6	10·3
6½	10·9
7	11·5
7½	12·1
8	12·8

TABLE XVI.

Cost of Slab, Beam, and Column Construction to carry 1 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span, and Slab with 1 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	7·0
1½	6·0
2	6·2
2½	6·6
3	7·1
3½	7·7
4	8·3
4½	8·8
5	9·4
5½	10·1
6	10·7
6½	11·3
7	11·9
7½	12·6
8	13·2

TABLE XVII.

Cost of Slab, Beam, and Column Construction to carry 1 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 1·2 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	7·0
1½	6·0
2	6·3
2½	6·7
3	7·2
3½	7·8
4	8·5
4½	9·1
5	9·7
5½	10·4
6	11·0
6½	11·7
7	12·4
7½	13·0
8	13·7

TABLE XIVA.

Cost of Slab, Beam, and Column Construction to carry 2 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 0·6 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	9·60
1½	7·45
2	7·36
2½	7·51
3	7·82
3½	8·21
4	8·68
4½	9·18
5	9·64
5½	10·15
6	10·65
6½	11·16
7	11·70
7½	12·25
8	12·83

TABLE XVA.

Cost of Slab, Beam, and Column Construction to carry 2 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 0·8 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	9·53
1½	7·48
2	7·40
2½	7·62
3	7·96
3½	8·42
4	8·90
4½	9·41
5	9·94
5½	10·47
6	10·98
6½	11·55
7	12·11
7½	12·69
8	13·32

TABLE XVIA.

Cost of Slab, Beam, and Column Construction to carry 2 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 1 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	9·48
1½	7·48
2	7·46
2½	7·69
3	8·09
3½	8·55
4	9·08
4½	9·62
5	10·22
5½	10·76
6	11·30
6½	11·91
7	12·51
7½	13·15
8	13·79

TABLE XVIIA.

Cost of Slab, Beam, and Column Construction to carry 2 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 1·2 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	9·50
1½	7·52
2	7·53
2½	7·81
3	8·24
3½	8·73
4	9·28
4½	9·86
5	10·49
5½	11·08
6	11·62
6½	12·28
7	12·93
7½	13·59
8	14·24

If we take these figures as a minimum for floors 11 ft. centre to centre, *i.e.*, 10-ft. column and 12-in. slab and beam in the average, the number of cu. ft. per super yard of floor will be $9 \times 11 = 99$, say 100, and the cost per cu. ft. of building will then work out—

For 1 cwt. per sq. ft. superload $= \frac{6 \times 12}{100} = 0.72$ penny.

2 cwt. $= \frac{7.36 \times 12}{100} = 0.88$ penny.

3 cwt. $\frac{8.6 \times 12}{100} = 1.03$ penny.

4 cwt. $= \frac{9.6 \times 12}{} = 1.15$ penny.

These figures, of course, do not include anything for wall beams, staircases, walls, or anything exterior to the ordinary floor construction.

Table XIVb. *Cost of Slab, Beam, and Column Construction to carry 3 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 0·6 per cent. Single Reinforcement.*

Table XVb. *Cost of Slab, Beam, and Column Construction to carry 3 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 0·8 per cent. Single Reinforcement.*

Table XVIb. *Cost of Slab, Beam, and Column Construction to carry 3 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 1 per cent. Single Reinforcement.*

Table XVIIb. *Cost of Slab, Beam, and Column Construction to carry 3 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 1·2 per cent. Single Reinforcement.*

Thickness of Slab. Ins.	XIVb. Total Cost in Shillings per sup. yd.	XVb. Total Cost in Shillings per sup. yd.	XVIb. Total Cost in Shillings per sup. yd.	XVIIb. Total Cost in Shillings per sup. yd.
1	11·6	11·6	11·5	11·3
1½	9·1	9·1	9·1	9·1
2	8·6	8·6	8·7	8·7
2½	8·6	8·7	8·7	8·8
3	8·8	9·0	9·0	9·1
3½	9·1	9·2	9·4	9·6
4	9·5	9·7	9·9	10·1
4½	9·9	10·2	10·4	10·6
5	10·4	10·6	10·9	11·2
5½	10·8	11·1	11·4	11·8
6	11·3	11·6	11·9	12·3
6½	11·7	12·1	12·5	12·9
7	12·3	12·7	13·1	13·5
7½	12·8	13·3	13·7	14·2
8	13·4	13·8	14·3	14·8

Economy in Reinforced Concrete Slab, Beam, and Column Construction.

(*i*) A rational arrangement of slabs and beams supported by columns is more economical than slabs supported by beams only.

(*j*) A low percentage slab reinforcement is more economical than a high percentage.

(*k*) A thin slab is more economical than a thick slab.

The writer suggests the thicknesses 3 in., 4 in., 5 in., and 6 in. as the minimum thicknesses, respectively, for the super loads, 1, 2, 3, and 4 cwt. per sq. ft.

DISCUSSION.

The discussion was opened by the reading of a letter from Mr. P. J. Waldram.

The following is an extract from the letter:—

"In a material which is heavy for its bulk, safety and economy are often synonymous. Where large spans or heavy stresses are involved, a sufficient factor of safety is often only made possible by the exercise of rigid economy in structural weight. Unfortunately, the value of Mr. Davenport's results as to unit costs, as they stand, obviously depend upon the accuracy of the fundamental data and upon the methods of calculating the sections compared.

"With regard to the formei, it would certainly appear that the prices quoted of 40s. per cub. yd. for concrete, and £10 per ton for beam and slab reinforcements are figures which are open to question.

"The stresses stated obviously limit the tables to 1 : 2 : 4 concrete, thus leaving out of consideration one of the readiest and most efficient means of securing the maximum economy in heavily stressed beams and in columns, viz., by the use of richer and stronger concretes in compression.

"The formulæ used for calculating double reinforced beam sections are not given.

"The conclusion drawn that double reinforcement is more economical than single is misleading.

"When the conditions of size and stress are such as to demand more than the economic ratio of tensile reinforcement, the strength of the concrete is the criterion of the moment of resistance. To attempt, under such circumstances, to assist the concrete by additional tensile reinforcements is almost futile, as can be seen from any curve of unit moments of resistance for varying proportions of reinforcement.

"The author also states that the most economical ratio of compressive to tensile reinforcement is 1 to 1. This depends upon circumstances."

TABLE XIVc

Cost of Beam, Slab, and Column Construction to carry 4 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 0·6 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	13·5
1½	10·4
2	9·8
2½	9·6
3	9·7
3½	9·9
4	10·3
4½	10·6
5	11·0
5½	11·4
6	11·8
6½	12·3
7	12·9
7½	13·4
8	13·9

TABLE XVc.

Cost of Slab, Beam, and Column Construction to carry 4 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 0·8 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	13·5
1½	10·5
2	9·8
2½	9·7
3	9·8
3½	10·1
4	10·5
4½	10·9
5	11·3
5½	11·8
6	12·2
6½	12·7
7	13·3
7½	13·8
8	14·4

TABLE XVIc.

Cost of Slab, Beam, and Column Construction to carry 4 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 1 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	13·3
1½	10·3
2	9·9
2½	9·7
3	9·9
3½	10·2
4	10·7
4½	11·0
5	11·5
5½	12·1
6	12·5
6½	13·1
7	13·7
7½	14·3
8	14·8

TABLE XVIIc.

Cost of Slab, Beam and Column Construction to carry 4 cwt. per Sq. Ft. Superload. Non-continuous T beams of 10 ft. Span and Slab with 1·2 per cent. Single Reinforcement.

Thickness of Slab. Ins.	Total Cost in Shillings per sup. yd.
1	13·2
1½	10·5
2	9·9
2½	9·8
3	10·0
3½	10·4
4	10·8
4½	11·3
5	11·8
5½	12·4
6	13·0
6½	13·4
7	14·1
7½	14·7
8	15·3

Professor Adams, M.Inst.C.E. (Vice-President C.I.), stated that there seemed to be a little confusion regarding the relative economy of single and double reinforcement. In the course of the paper the author stated that double reinforcement is not necessarily less economical than single reinforcement. Then, further on, he stated that doubly reinforced plain beams with 1 per cent. tension and compression steel are more economical than singly reinforced plain beams.

With regard to the statement, "Any smaller depth ratio of depth to breadth than 3 to 1, would bring the neutral axis inside the slab and the beam would then no longer be a T-beam," he had always considered whether the neutral axis is within the flange or within the web it is still a T-beam.

With regard to the statement that "The elimination of columns increases the cost of construction," he took this to mean the elimination of columns altogether, not taking the case where they are used with main beams.

Mr. E. Flander Etchells, F.Phys.Soc., M.Math.A., A.M.I.Mech.E., M.C.I., said that the paper had the one advantage in it that it showed a far more scientific way of obtaining economy than is frequently adopted by builders who are very anxious to get a particular order in the face of rivals who have an equal chance of procuring same. In that case a common device is to increase the working stresses in an arbitrary manner and decrease the bending moments in the same way. With regard to the author's remarks on the economy in reinforced concrete (square) column construction, the word "helical" is rather ambiguous. As used in the R.I.B.A. Report, the word "helical" is restricted entirely to lateral reinforcements in the form of a cylindrical screw, and not a form which is square on plane. The point is important, because if the author in his paper has taken the form factor for helical reinforcements when he has had in mind lateral reinforcements which are square on plane, then the result of equations in that case will not be in accordance with the R.I.B.A. Report.

With regard to the author's suggestion as to slab thicknesses of 3 in., 4 in., 5 in., and 6 in. as the minimum thicknesses respectively for the superloads, a word of warning is needful to those who may be building within the County of London, and that is that the load on the floor is not the only factor in determining its thickness. In many cases the Building Acts require fire-resisting construction, and half an inch or one inch of reinforced concrete is not considered fire-resisting.

Mr. R. W. Vawdrey, B.A., Assoc.M.Inst.C.E. (Member of Council C.I.), said he thought that £10 per ton for the main reinforcement (bent and fixed) was altogether inadequate. He went on to remark on the difficulty of confining considerations to bending moments only, and whilst it might be necessary to confine one's attention to bending moments for such a purpose as that of this paper, it is a fact that all these per cents. and general descriptions of methods are vitiated to a very great extent by the question of shear. In a great many cases it is that far more than the bending moment on the beam which really determines the design. As to the general principle that has been adopted by the author, he thought the idea of working out in such detail the actual costs under various conditions was an excellent one.

Mr. Ewart S. Andrews, B.Sc. (Lond.), M.C.I., said he did not see why the author should have given values for double reinforcement below what is commonly called the economical percentage, ·675, because it seemed almost obvious that it was unnecessary below those values. With regard to the T-beam formula, he thought it would have been rather more satisfactory and valuable, since most of the calculations have followed the R.I.B.A. figures, if they could have been followed without much additional work to those T-beams.

Mr. M. Noel Ridley, Assoc.M.Inst.C.E., M.C.I., said there were several things in the Tables he did not quite understand, and referring to Table II. he said he did not quite see why the author put the width of the beam 13·9, taking the 1,000,000 lb. resistance for a metal of 5·78 sq. in. He thought in some cases the single reinforcement had been taken in the bottom instead of double. Of course, there it would be usually double, and the width of the beam would be about 8 in. instead of 13·9.

Mr. E. C. Williams, B.Sc.: T-beams, being the major part of a building in reinforced concrete, must of necessity be the most important part of this Paper. In Table II., on T-beams, 4-in. slab, with 1,000,000 lb. bending moment, after the cost of the beams 10 ft. long, comes the factor of concrete, which is here a varying factor. Now, a beam with a fixed bending moment over a span of, say, 10 ft., would of necessity have a fixed shear. If that shear is constant, and we usually take 60 lb. a sq. in. on the concrete, then the concrete area must be constant. This concrete area does not enter into the consideration, of course, and the question of cost depends entirely upon the ratio of side centering for steel reinforcement, and there must be a factor of the bending moment.

Then, again, as regards the slab, he had worked out the question of cost for the slab himself, and found that that slab would be cheaper provided the cost of the steel in the slab were equal to the cost of the concrete. The centering cannot come into the question of cost at all. As regards the slab, it is purely a question between the concrete and the steel, whereas in a T-beam it is a question between the side centering of the beam and the steel.

MR. DAVENPORT'S REPLY.

Mr. Davenport: In replying to Professor Adams regarding the elimination of columns, the author said he had taken two schemes. First of all a 20-ft. floor supported on non-continuous beams 20 ft. of span, and worked up the costs, thus getting so much per superficial yard for the various thicknesses per yard of superloads. Then he obtained the effect of reducing the spans of the beams by adding a row of columns, which gave the cost per super. yard, and hence the statement that the elimination of columns, that is increasing the spans of beams, increases the cost.

Regarding the point raised of the T-beam with a neutral axis in the slab. This would be a T-beam, with a very much thinner slab, and the same benefit would not be derived from that as compared with the full depth of the slab acting in compression. The compression area is reduced, and of course the total compression, that is, the total push, due to the stress in that concrete is reduced also, and the moment of resistance is reduced unless it is increased by doing something else, either increasing the breadth or in some other way. The question of double and single reinforced beams was put forward. In one place it is stated that they are more economical, and in another place that they may be more economical. For the cases considered they are more economical, but in the Paper these costs are taken for a special reason, not necessarily because they are the best costs, but they are simply costs which would enable anybody, if they wished, to get costs of construction to any other unit cost by simple proportion.

Replying to Mr. Etchells's remarks as to the thickness of the slabs, and the question of fire-resistance, the author remarked that he had not considered the question of fire-resistance at all, as this came under the heading of Architectural Economy.

Replying to Mr. Vawdrey's suggestion that £10 per ton for the steel was too low, the author remarked that this might be so, but it formed a good basis to work from.

After replying to several other speakers' remarks in detail, the meeting was terminated.

NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

"A Treatise on Cement Specifications." By Jerome Cochran.
London: Constable & Co. 1913. 6/- net.

Although this work bears an English publisher's name on the title-page, it is entirely American in object and scope. The author admits that American specifications go into less detail than those of Europe, and it is not likely that engineers in this country will learn much from the specifications here printed, although the compilation will no doubt prove of value to their American colleagues.

Both natural and puzzolan (slag) cement are used in the United States, but it is interesting to note that the employment of either is excluded in the construction of reinforced concrete work or of any structure subjected to severe or frequently recurring structures, for which purposes only Portland cement may be employed.

The tests described are similar to those generally used, except that the boiling test with thin pats is prescribed for the detection of unsoundness, the Le Chatelier test not being mentioned. The requirements as to fineness are much less stringent than those of the British Standard Specification. The limit of magnesia is fixed at 4 per cent., and that of SO_3 at 1·75 per cent. There is a useful bibliography of American publications relating to the testing of cements, with a few European references.

"Reinforced Concrete Doors."

Red Book of the British Fire Prevention Committee No. 173, dealing with Fire Tests with 3 reinforced Concrete Doors, constructed for Experimental Purposes to the Design of Commandant Welsch, Chief Officer Ghent Fire Brigade. Published at the Offices of the Committee, 8 Waterloo Place, Pall Mall, S.W. Price 3/6.

The doors tested and reported upon in this Red Book are of a non-proprietary character, and were designed in Belgium in the public interest by Chief Officer Welsch, who is the Chairman of the Belgian Government Technical Committee on Fire Protection.

The doors under test comprised two single doors to two openings, fitted as sliding doors, and one set of double sliding doors fitted to a third opening.

In the prefatory note it is stated that "although the idea of constructing doors of concrete is not new, yet the use of such doors has been quite exceptional."

Single Door No. 2 (Fire Side) after Test.

A study of the Report will show that the tests were highly interesting, and they went to prove that—subject to the remedying of some minor defects in construction —reinforced concrete doors would be a valuable addition to our fire-resisting materials.

The two single doors were tested for a period of 2½ hours at a temperature gradually increasing to 1,800° F., but not exceeding 2,000°, and the double doors were tested for a like period under similar conditions. In each instance water was applied at the conclusion of the test for two minutes.

All the three doors tested had a dimension of approximately 4 ft. by 7 ft.

A full log showing the progress of the tests is given. The Report contains illustrations of the construction of the doors, together with numerous photographic views of the doors before and after test.

By the kind permission of the Committee we are here reproducing a view of one of the single doors showing the fire side of Door No. 2 after the test, and after the door had been removed.

All the dimensions, etc., in the Report are, as usual, accompanied by their metric equivalents.

A German edition of the Report has been published by the Committee's Continental publishers.

"Staircases in Reinforced Concrete and Artificial Stone" ("Eisenbetontreppen und Kunststeinstufen.") By Karl Matthies.

Berlin: Verlag der Tonindustrie-Zeitung. 1913. Price M.2.25.

The construction of staircases in concrete or artificial stone is a very common proceeding, whilst complete, self-supporting staircases of reinforced concrete have been introduced into many modern buildings, but the statical computation and design of such structures are complicated, and probably few engineers are familiar with them. For this reason the present work, which describes the usual forms of construction and deals in detail with the nature of the stresses and the methods of computation, will be found useful. It is important to note that the choice of a type is often governed by local building regulations relative to fire-proof staircases. Methods of testing are also described, including a method involving the use of a small portable hydraulic press, by means of which a load may be applied to one or more steps at once, and which may be found useful in other cases where it is required to test beams and other structural members on the spot, without removal to a specially-equipped laboratory.

The book is fully illustrated.

"A Primer of Cement" ("Zementbrevier.") By Dr. Hans Kühl.

Berlin: Verlag der Tonindustrie-Zeitung. 1913. Price 30 Pf.

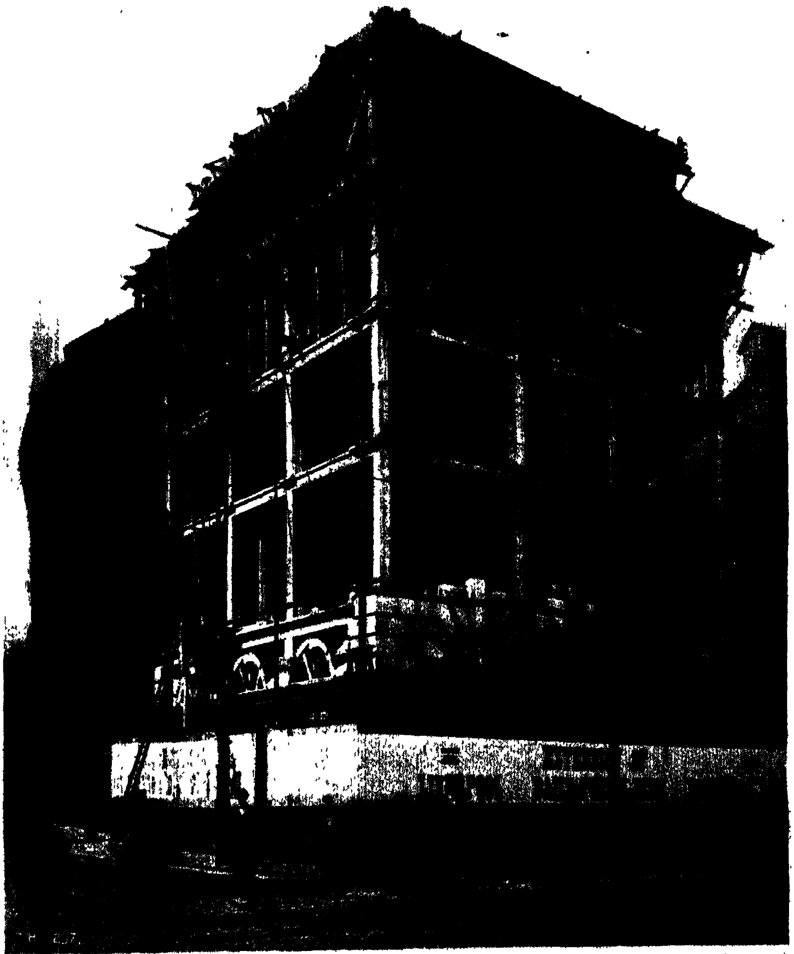
This excellent little compendium, a pamphlet of only 70 small pages, contains a remarkably complete statement of the essential facts relating to cements, their manufacture, properties, and use. The different types of cement (Portland, natural, iron-Portland, slag, etc.) are described and defined, and the methods of testing and the standards to be attained are enumerated in detail. The last section deals with the methods of mixing mortar and concrete for various purposes, including reinforced concrete construction, and the best proportions and character of aggregate, etc., for each case. The information given is both concise and accurate.

NEW WORKS IN CONCRETE
AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

NEW OFFICES FOR THE "LIVERPOOL DAILY POST."

SOME new premises have recently been erected and completed for the *Liverpool Daily Post.* The two great points which had to be taken into consideration in the erection



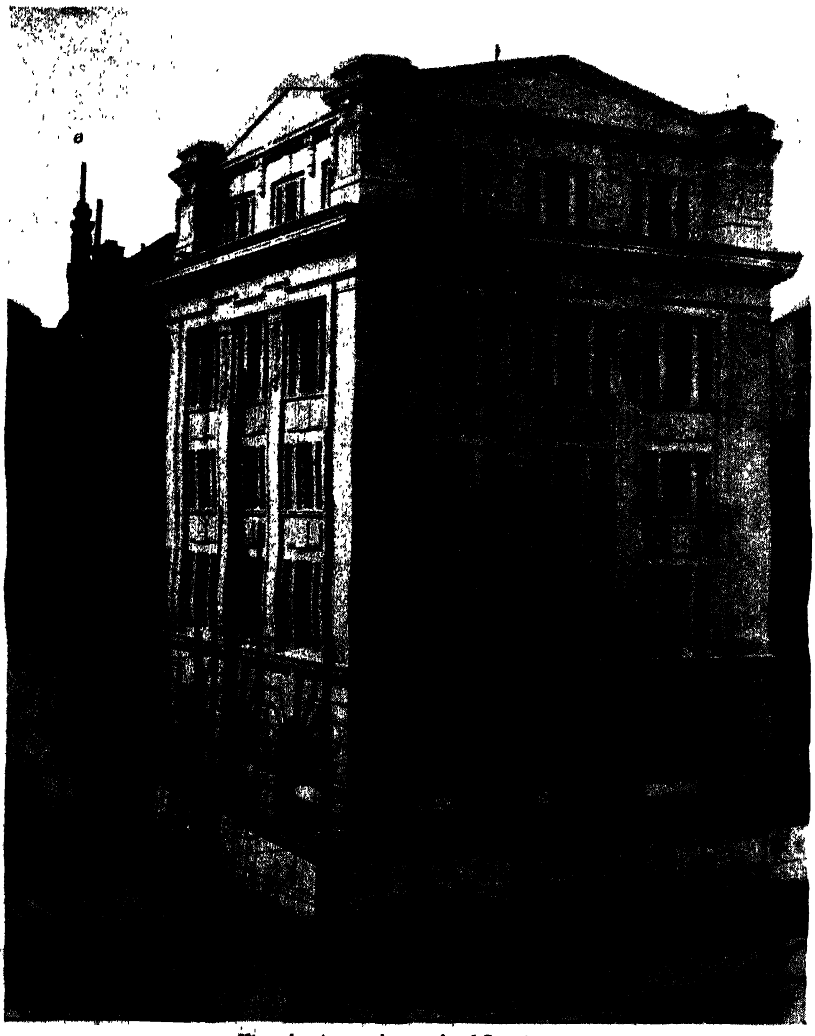
View showing Building in course of construction.
NEW OFFICES FOR THE "LIVERPOOL DAILY POST."

of the building were economy of space and safety against fire, and it was found that both these problems were solved by the employment of reinforced concrete.

The building is an extension to the existing offices. There are six stories in addition to a basement, which houses the engines. The walls are carried from floor to

floor by a reinforced concrete frame, and the floors are designed for a super-load of 3 cwt. per sq. ft., and they are 4 in. thick. The building is of fire-resisting construction throughout.

The details of the reinforced concrete work were designed in collaboration with the architect, Mr. Aubrey Thomas, by Messrs. L. G. Mouchel and Partners, Ltd.,



View showing nearly-completed Structure.
NEW OFFICES FOR THE "LIVERPOOL DAILY POST."

Westminster, S.W. The contractors were Messrs. Edmund Nuttall Co., of Manchester, and the builder Mr. John Williams, of Liverpool.

REINFORCED CONCRETE QUAY FRONT AT WESTPORT, IRELAND.

WHEN the Westport Harbour Commissioners some time ago decided to extend the Westport Harbour Quay, they considered the use of reinforced concrete, masonry, and timber construction.

After getting preliminary tenders it was decided to erect a reinforced concrete structure, and designs and tenders were invited from a few specialist firms.

The design adopted was as shown in *Figs.* 1 and 2, and the work was carried out accordingly.

The quay front, which is about 200 ft. long, consists of a row of main piles 14 in. by 14 in. section and spaced 6 ft. centres. Behind the main piles close sheet piling is driven in order to retain the sand filling.

The sheet piles are 8 in. by 14 in. in section, and the pressure exacted on them by the filling is transmitted to the main piles by three rows of horizontal walings, 12 in. by 12 in. in section, two placed close together just above low water level and one placed somewhat higher up. On top of the main and sheet piling a heavy horizontal beam is built, tieing all the piles together at their upper ends, and serving as a base for the upper wall or apron.

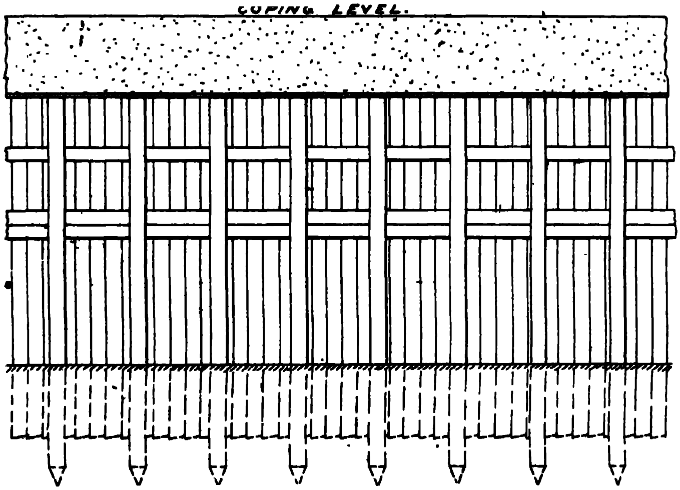


Fig. 1. Front Elevation.

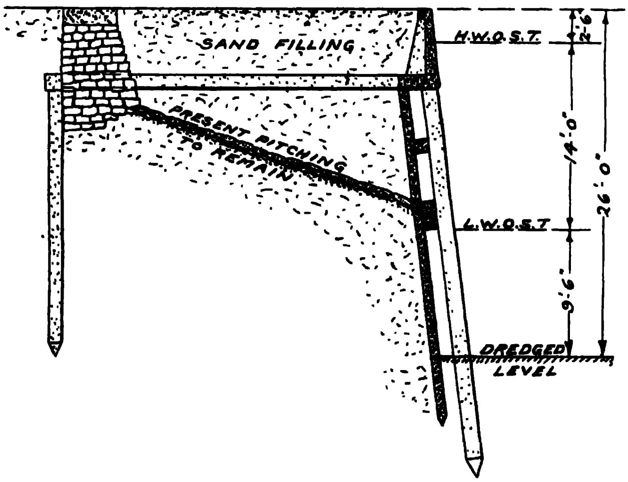


Fig. 2. Cross Section.
Westport Quay Extension, Ireland.

This consists of a nearly vertical slab, supported by a coping beam at its upper edge and by buttresses spaced 6 ft. centres, and placed just above the main piles.

The front edge of the coping beam is protected by a heavy steel angle, fastened to the concrete by means of rag bolts with countersunk heads.

The whole front part of the structure is tied back to the anchor piles by means of 12 in. by 12 in. tie beams, spaced 6 ft. centres, one to each main pile, and carried through an old rubble wall, behind which the anchor piles are driven.

In some places, where a building comes up close to the old rubble wall, it was found necessary to drive the anchor piles in front of this wall, but the tie beams were in all cases run through the wall, and concreted into it.

There is one anchor pile to each tie beam, and they are 12 in. by 12 in. in section.

After the reinforced concrete work had been finished the space between the old rubble wall and the new reinforced concrete front was filled with sand, and the dredging could then be proceeded with.

Three heavy timber fender piles were also driven in front of the reinforced concrete piles, and were carried up to 5 ft. above quay level and braced to the reinforced concrete, so as to serve as mooring posts also, as shown in *Fig.* 3.

The Engineer for the work was Mr. E. K. Dixon, M.I.C.E., County Surveyor for the County Mayo, and the reinforced concrete work was designed and carried out by Messrs. J. & W. Stewart, of Belfast, London and Dublin.

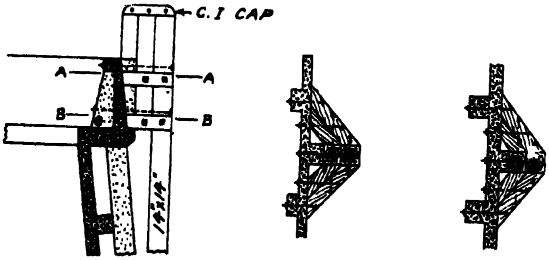
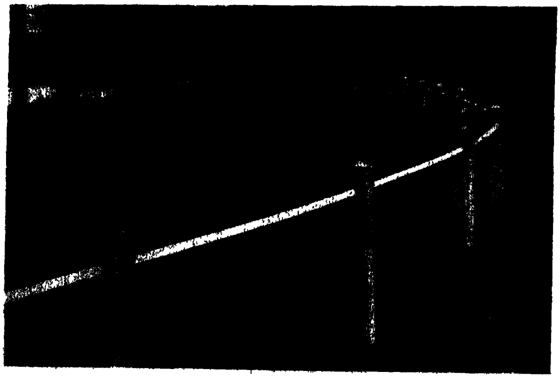


Fig. 3. Side View. Section AA. Section BB.
Details of Timber Fenders.
WESTPORT QUAY EXTENSION, IRELAND.

REINFORCED CONCRETE POSTS AT GROVELANDS PARK.

THE accompanying illustration shows some patent reinforced concrete posts used for fencing round the lake in the picturesque new park at Grovelands, Palmers Green, which was opened to the public last month. The posts are of York stone chippings and Portland cement concrete, 5 ft. long and 5 in. square, and have a neat cap of ornamental design. They are placed 8 ft. 6 in. apart, but closer on sharp curves, and are reinforced with rib mesh expanded steel supplied by the Expanded Metal Co., Ltd., of London and West Hartlepool, bent into column form, and are very strong and durable. For situations near water, these posts are especially suitable, as they are impervious to rot or decay, and indeed become stronger with age. They carry a 1½ by 1½ square iron bar set anglewise in the posts, and the fencing is pleasing in appearance. The posts never vegetate but retain the natural stone colour, and there is no necessity to paint them, so that they are well adapted for park or roadside fencing.

The fencing has been carried out by Messrs. Tidnam and Co., concrete specialists, of Wisbech, from the designs and superintendence of Mr. C. Griffin Lawson, A.M.I.C.E., the Engineer and Surveyor to the Southgate Urban District Council.



Reinforced Concrete Posts
GROVELANDS PARK, PALMERS GREEN.

CONCRETE IN EGYPT.

THE magnitude of many of the great works in Egypt—such as the Assuan Dam—in the construction of which concrete forms the main element, is, from repeated description, well known.

Concrete, however, has other, if smaller, fields of utility in the land of the Pharaohs, one of these being that which the Egyptian Delta Light Railway Company, Ltd., finds for it.

For a long time this Company was confronted with the problem of erecting quarters for certain of its subordinate station officials (native Egyptians) at a cost which would enable a rent to be charged commensurate with the necessarily small salary drawn by those officials, and yet provide a reasonable rate of interest on the capital outlay. Reinforced concrete afforded the only practicable solution, after extensive trials.

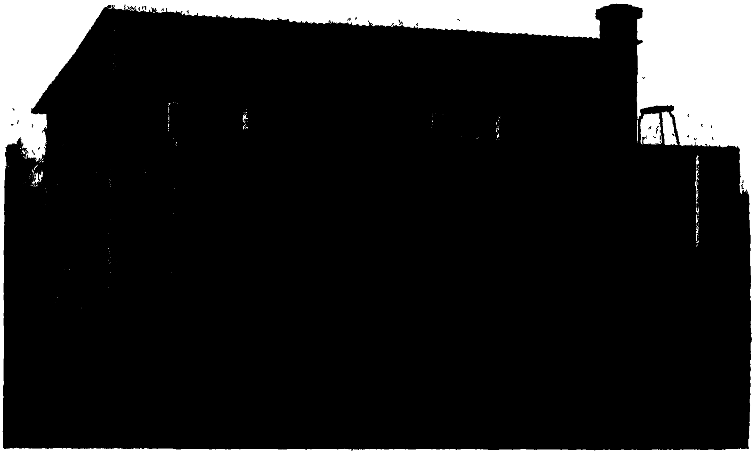
The unit is one room and an enclosed courtyard for menials, with two rooms and a courtyard for assistant station masters, and three rooms and a courtyard for station masters. Each room has an area of 3 by 3 m., a height in front of 3 m. and at the

rear 2·50 m. The single courtyard is 2·50 m. broad by 3 m. long, and the double courtyard 2·50 m. broad by 6·20 m. long, all inside measurements.

The walls are built of concrete, the method of construction being as follows: Timber moulds were first of all made according to drawings at a cost of £15. These are then placed on the ground at the site of the building longitudinally, so arranged as to come into position when raised vertically. The insides are coated with oil and the reinforcing element—consisting of discarded semaphore wire—is laid in such a manner as to form a network, the ends extending some 2 ft. outside. The window and door for each unit is then put in place. The concrete mixture consists of—

½ in. diameter Abou Zaabal gravel, 3½ parts.
Fine sand, 1½ parts.
Gillingham Portland cement, 1 part.

It is poured into the mould and subsequently kept moist by means of wet sacks, being left to set for seven days. The sides of the moulds are removed and the slabs, now

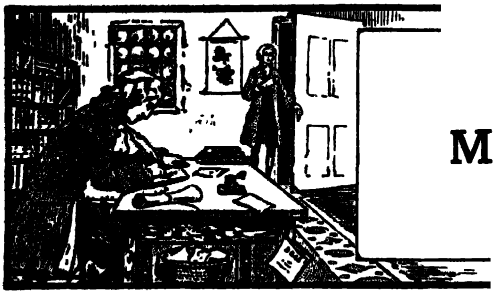


Double Unit Reinforced Concrete Hut.
STAFF QUARTERS, EGYPTIAN DELTA LIGHT RAILWAYS.

set, are raised on end into position by means of a winch and shear-legs. The edges are joined by the passing of a ¾ in. dia. iron rod vertically and looping the projecting ends of the reinforcing wire round it, subsequently giving the whole a covering coat of cement.

The whole of the structure has a clean face and requires no touching up whatsoever. The roof is of ordinary galvanised iron.

The cost of constructing the single unit, one room and courtyard, in the manner described is £12, the double unit like the one illustrated costs £25, and the treble unit £40. The annual rent is fixed at 10 per cent. of this, and is gladly paid by the staff, as no equally substantial habitation, and one so easily kept clean, can be obtained locally for double the sum, and the amount is well within the means of even the lowest paid employé.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Application of Reinforced Concrete to Rural Housing.—In the course of an interesting paper on the subject of reinforced concrete generally, read before the Surveyors' Institution last month, Mr. Percy J. Waldram spoke at some length as to the possibilities of using reinforced concrete to solve some of the difficulties of building cheap cottages in rural districts. He pointed out that the essential requirements of cottages and small houses in rural districts are (*a*) that they should be inexpensive, but efficient and durable; (*b*) that the walls should not only be weather and damp proof, but form an insulation against changes of temperature; (*c*) that they should not disfigure the landscape; and (*d*) that they should be sufficiently substantial and fire-resisting to comply with reasonable or reasonably interpreted by-laws.

The author stated that there could be little doubt that a cottage built of reinforced concrete in the form used for warehouses and office buildings would be extremely costly. But there were other ways in which the properties of cement concrete and the particular advantages of reinforced concrete could be enlisted.

He pointed to the hollow concrete building blocks made by hand machines which any intelligent labourer could operate, and went on to show the different ways in which these blocks can be employed and finished off.

He described various ways in which the reinforced concrete could be applied advantageously and economically, and how, by adopting certain methods in wall construction, saving could be effected. The paper was followed by a discussion.

New Wharf for Dundee in Reinforced Concrete.—The Dundee Harbour Trustees have decided to construct a new wharf of reinforced concrete. The wharf is to be 650 ft. long and 60 ft. wide. The total estimated cost, including necessary equipment, will be about £120,000.

The British Fire Prevention Committee's Testing Station.—The British Fire Prevention Committee's Testing Station, which has been recently remodelled and enlarged, is to be opened for its new session on Wednesday, May 7th, and an interesting series of fire tests, with both non-proprietary and proprietary building materials, has been announced for the coming summer.

On the opening day the tests are to be with fire-resisting glazing and with reinforced concrete party-wall doors, and a large attendance from the various Government Departments concerned, who subscribe to the Committee, is expected.

On the opening of the Testing Station, it will be found that the relics of previous tests, as far as they were still available, have been arranged to serve as technical exhibits—partly as out-door exhibits and partly indoor—and these collections are to be materially extended and catalogued.

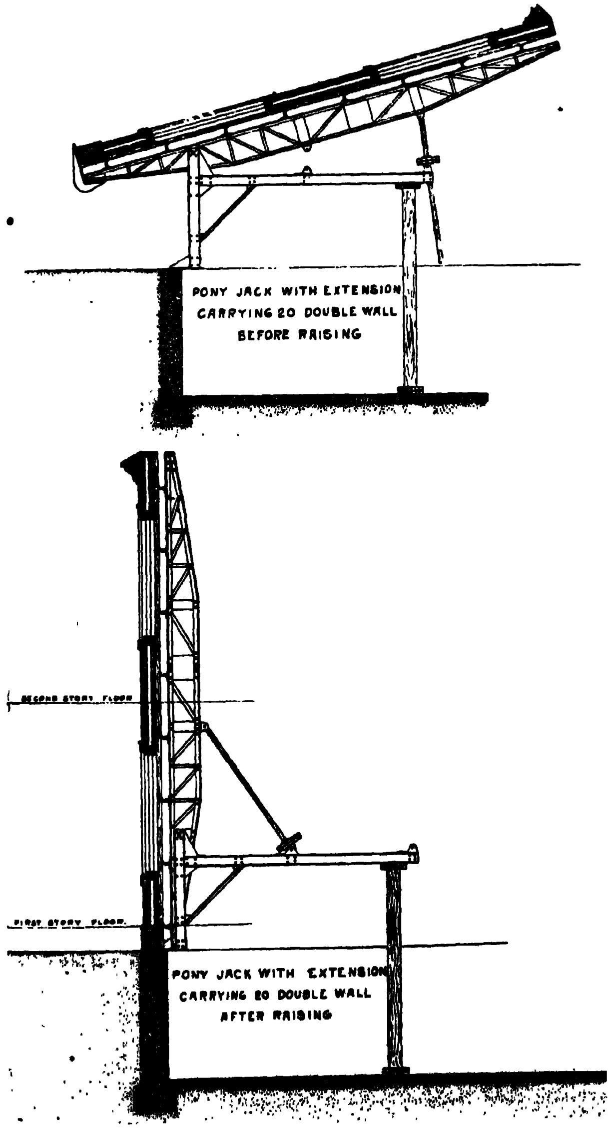
Fire Protection in Theatres.—A model theatre has been built at Dusseldorf, in order to test the dangers of theatre fires, and the best means of rendering theatrical buildings proof against fire. It occupies a site measuring 50 ft. by 80 ft., with the auditorium 30 ft. and the proscenium 40 ft. high. The main part of the building is of steel and reinforced concrete. A special entry enables observations to be made both in the front and the rear, and two kinds of fireproof curtains will be fitted. Seats are to be provided with the intention of testing various processes for rendering them fireproof.

Raising Reinforced Concrete Walls with Jacks.—The accompanying drawings (Figs. 1 and 2) show the design and method of operation of wall-raising jacks for reinforced concrete buildings and the structures in process of erection. The photographs, Fig. 3, shows the officers' quarters as well as the barracks buildings at

Fort Crockett, Galveston, Texas, built in this manner, the latter building measuring 187 ft. long and 58 ft. wide.

The quartermaster's store-house—116 ft. long—at Crockett was also built in this manner, the walls being raised into place in 4½ hours by these jacks. The front wall of the post exchange and gymnasium building at Galveston, Texas, weighing 243 tons, was erected with these raising jacks.

The concrete walls of the Military Academy at San Antonia, Texas, were also completed in a horizontal position, the reinforcement being readily employed with small labour cost, and the completed walls raised into a vertical position by these power jacks.



Figs. 1 and 2.

At Deerfield, Ill., a business structure 60 ft. by 60 ft., with two apartments on the second floor, was erected at a cost of only $18,000, including plumbing and heating. This building has monolithic concrete walls, light courts, and roof.

It is maintained that this system of reinforced concrete building construction is a simple solution of the concrete problem. The expensive wooden or metal forms often make the cost of a form-built structure very high.

The weakness of a wall built in forms is caused by the horizontal stratas of cement, sand, and gravel, which result from pouring two or three feet (vertically) of a wall each day; this is essential in form construction, while the length of time consumed in building forms and pouring cement in them is so great that many owners and architects are loath to undertake the proposition.

It is held that all of the above-mentioned difficulties have been successfully overcome by this method. The system is simple and unique. On this and on piles inside of the building lot are set a series of steel jacks. These jacks consist of a supporting carriage, a pivoted walking beam, and a collapsible screw driven by a worm gear and worm. A platform is then laid on the jacks, and on this platform are set in their proper relative positions all door-frames, window-frames, and other openings. Now the concrete is poured around the openings of this construction.

The reinforcement is easily and properly placed both horizontally and vertically, because the wall resembles a great draughting-board, and is very readily "laid out." If an air space is desired, it is only to be filled in with loose sand, which is removed before the wall is entirely in place. When the entire wall is poured—and this can be done in a single day, even though the wall be 200 ft. long and three stories high—and the finish desired is put on the outside surface, it is all level like a huge work-table.

After the wall is finished, it is allowed to set for forty-eight hours; then a small gasoline engine or electric motor is connected to the driving-shaft and the wall rises from the inside slowly and quietly to its permanent vertical position.

The space between the wall and foundation is pointed up and properly braced, and then comes the removal of the jacks, which are bolted to anchors set in the wall.

FIG. 3. OFFICERS' QUARTERS AND BARRACKS BUILDING, FORT CROCKETT, GALVESTON, U.S.A.

When all the walls are in place, the corners where reinforcement from either wall project and interlock are then poured, and there is a complete monolithic, well-finished structure. The floors and roof of concrete, or of any construction desired, are then put in in the same way as in any other building.

No forms whatsoever are used in the wall construction excepting the wooden jack platform, which is never destroyed, but is used over and over again. The reinforcement is placed both horizontally and vertically exactly where it belongs in both inner and outer walls and rods. Fabric or any other kind of reinforcement may be used without the slightest difficulty. It is claimed that a building can be constructed in two-thirds of the time required for brick construction.

Strength Coefficients of Reinforced Concrete Telegraph Posts.—The Service de l'Electricité of the Brussels Municipal College has informed the Union des Exploitations Electriques that its consultative committee on safety measures has adopted the following coefficients for telegraph posts made of reinforced concrete. When such posts serve to take wires across a railway, the concrete must stand a compression stress of 30 kg. per sq. centimetre (427 lb. per sq. in.), and the metal a tensile strain of 800 kg. per sq. centimetre (11,378 lb. per sq. in.), but when the telegraph line follows or crosses a road or waterway these figures must be increased to 35 kg. (498 lb.) and 1,000 kg. (14,223 lb.) respectively.—*Contract Journal.*

Buildings on Reinforced Concrete Raft.—Messrs. Cory and Son, Ltd., the well-known coal factors, have recently carried out a well-devised scheme for the provision of dwellings for the class of unskilled labour employed at their coal derricks and barge works at Charlton.

The site, of three acres, is situated in the Charlton marshes, with a frontage to Anchor and Hope Lane. The eighty-two dwellings are arranged in two-floor self-contained flats, with separate entrances, grouped around secluded and gated quadrangles planted with trees.

The accommodation of each flat consists of four, five, and six rooms, graded to meet the means and family requirements of the varying classes of labour employed

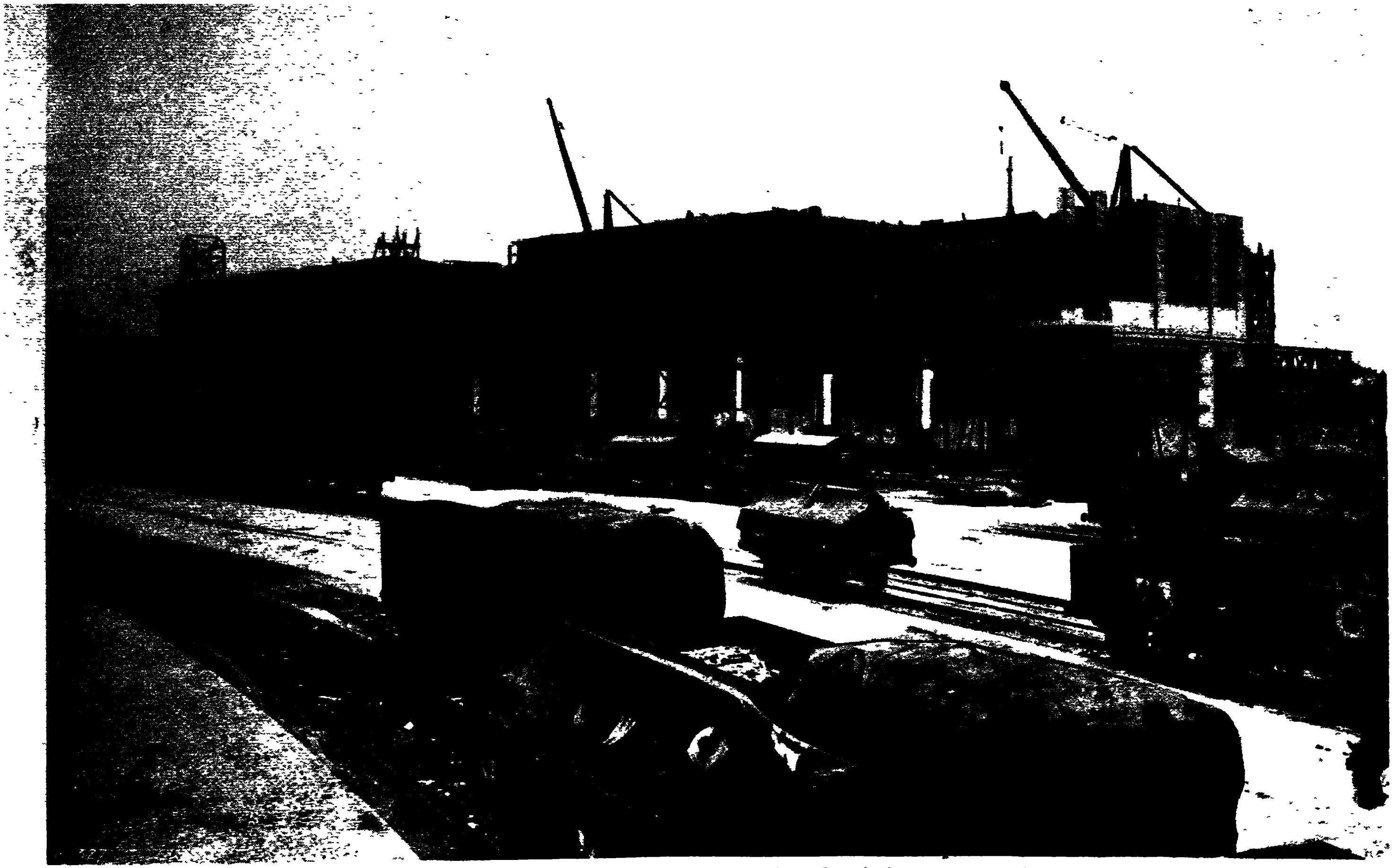
in the coal industry. The nature of the foundation, which was a mud shoot several feet deep on a peat bottom, necessitated special precaution and a 6-in. reinforced concrete raft laid over the entire site of the buildings. The absence of back-additions enabled the weight to be distributed evenly over the raft, and although some of the buildings have been completed over two years no sign of structural failure has appeared.—*Building News.*

TRADE NOTICES.

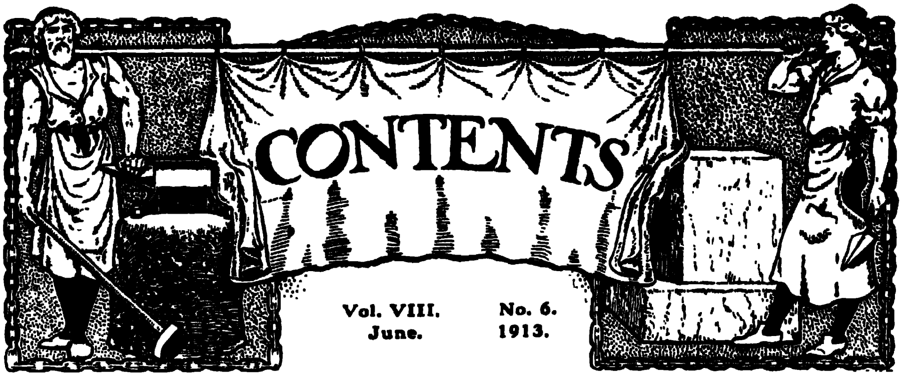
Corporation of Pontefract; New Baths in Reinforced Concrete.—Mr. A. Nunweek, of Sheffield, the architect whose design was accepted in open competition for the above, has decided to construct the baths, subways, floors, etc., in "Piketty Concrete." The contract is being executed by Messrs. James Fidler, Ltd., of Sheffield, who are licensed contractors of Messrs. Paul Piketty and Co., Reinforced Concrete Engineers, 14, Bloomsbury Street, London, W.C.

Harwich: New Landing Stage in Reinforced Concrete.—The Corporation of Harwich has decided to construct the new landing stage (length 250 ft.) in reinforced concrete, and has adopted the plans of Messrs. Paul Piketty and Co., Reinforced Concrete Engineers, London.

The work will be carried out forthwith by Mr. T. W. Pedrette (licensed contractor for the "Piketty System"), of Enfield, N., whose tender has been accepted.



View of Goods Station during Construction. *(For description see page 375.)*
SOUTH LAMBETH GOODS DEPÔT.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June. 1913.

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume VIII. No. 6. LONDON, JUNE, 1913.

EDITORIAL NOTES.

THE CONCRETE INSTITUTE.

ANNUAL GENERAL MEETING.

THE Annual General Meeting of the Concrete Institute took place on May 22nd, when the report for the session 1912-13 was presented by the Council. This Report shows an increasing activity in the Institute's work during that period, and it certainly indicates the wide scope of its usefulness, if full advantage is tactfully taken of the great technical talent to be found among the membership. This we do not think has been the case during the last few years, otherwise there would not have been so many resignations from its Council, and, what is more, the retirement of just those members who would be among the most valuable and experienced available.

Last year the Council lost a number of most useful men, and this year we find that men like Mr. Bertram Blount, F.I.C., and Mr. C. H. Colson, M.Inst.C.E., of the Admiralty, are giving up their seats. When men of this character retire it is always a sign that the Council meetings do not really interest them, or are looked upon as a waste of time. An uninteresting Council meeting is practically a sure indication of one devoted too largely to administrative routine as distinct from technical advancement, and, maybe, this is the case when we read of the Institute again changing its rules, re-arranging its objects, and classifying the membership when there is so much useful and technical work to be achieved. Surely these continuous changes are not necessary.

But it is very obvious from the report that the real work of the Council is actually done by the Standing Committees, comprising partly members of Council and partly members co-opted from the general membership.

It is a healthy sign to observe the extensive work done by these committees, and the comprehensive character of the problems still under consideration. It seems to us that it is the Committees rather than the Council that are upholding the dignity and advancing the interests of the Concrete Institute. Particular congratulations should be accorded to the Science Standing Committee, which is certainly doing most admirable work.

As to the recent tendency to make the Concrete Institute what might be termed an "Institution of Structural Engineers," the idea being to give "Concrete" *per se* a subordinate place, we note that no very great advancement has fortunately been made in this line of thought. The Institute must obviously deal with much that relates to structural engineering, but if it is

to hold its own it should be the Concrete Institute and nothing else, and if so-called engineers are really desirous of having their own little society, there is ample opportunity for some active genius to form such a body without entrenching on the greater and more influential body whose interests are directly concerned with that vast subject covered by the title of "Concrete"—a subject, by the bye, which is rapidly becoming quite as great as the subject of iron and steel, dealt with by the Iron and Steel Institute, an association also connected with the subject of structural engineering.

It is pleasing to observe that the membership is increasing, and with the honorary members the figure of 1,000 has been reached. But quantity alone does not make an influential membership, and thus the Institute would be very well advised to be more careful than it has been in the last two years in the acceptance of candidates applying for enrolment.

Financially the Institute has done remarkably well, and congratulations should be specially accorded in this direction to the President, Mr. E. P. Wells, who, by careful economy, has kept the expenditure within the Institute's resources. Being essentially technical, rather than humane in its objects, the Institute cannot rightly have claim either to the enthusiasm or the charity of those benevolently inclined to help Science and Humanity. To do really good work the present income of £1,000 requires increasing to £2,000, and whether eventually it will not be wise boldly to take the grave step of even increasing the subscription for existing members is a matter which certainly claims consideration.

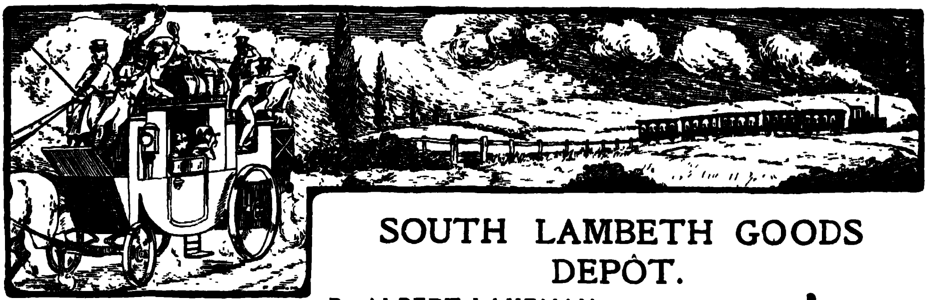
Speaking generally, therefore, excepting for a certain loss of the Council's prestige of late, the Concrete Institute has made good progress, and, given greater energy, there is no reason why the impending year should not be more successful than the year that has past.

THE LOCAL GOVERNMENT BOARD AND REINFORCED CONCRETE.

An interesting feature in the Annual Report of the Concrete Institute is the reproduction of the letter from the Local Government Board to the Concrete Institute on the matter of the Repayment of Loans in respect of Works of Reinforced Concrete Construction.

This letter, dated April 14th, 1913, is printed below, and we reserve our observation for a future occasion:—

> I am directed by the Local Government Board to advert to your letter of the 28th ultimo, with reference to the period allowed for the repayment of loans sanctioned by them to local authorities for the construction of works of reinforced concrete, and I am to state that the Board have fixed no single period. Each case is dealt with on its merits, having regard to the purpose of the work and its position. Generally speaking, however, the following terms are taken as a basis in calculating the periods to be allowed in respect of the more common terms of ferro-concrete construction:—
>
> Bridges with flat super-structure properly protected by a layer of asphalte or other suitable material; reservoirs and tanks containing liquid—10 years.
>
> Arched bridges protected from moisture by a layer of asphalte or other suitable material; chimney shafts; tubes—15 years.
>
> Floors of building subject mostly to dead loads and properly protected from electric currents and damp—30 years.



SOUTH LAMBETH GOODS DEPÔT.

By ALBERT LAKEMAN.

One of the most interesting applications of the use of reinforced concrete in structural work is its extensive and increasing use for railway work of every description, and the following article on the South Lambeth Goods Depôt contains many points of special interest.—ED.

THESE large premises have been erected for the Great Western Railway Company in South Lambeth on a portion of the site formerly utilised by the Vauxhall and Southwark Waterworks Company for filter-beds from the designs of Mr. W. Armstrong, M.Inst.C.E., the engineer for new works to the Great Western Railway.

The premises include a large goods station and warehouse, office buildings and stables, together with numerous sidings and tracks for the traffic and also storage purposes, the whole scheme providing splendid facilities for the collection and delivery of goods in South London. Direct communication is afforded with the Great Western Railway system *viâ* Battersea and Acton, and connection is also given to the various railway systems passing through Clapham Junction.

Many interesting constructional features are to be found in the buildings, particularly in the goods station and warehouse portion, the material used being reinforced concrete designed on the Hennebique system by Messrs. L. G. Mouchel and Partners, of Westminster, the minimum number of supports being used in the ground floor to avoid obstruction in the loading and unloading of the goods. This main building is about 400 ft. long by 72 ft wide, and it has a total height of 86 ft. from the foundation level to the top of the parapet.

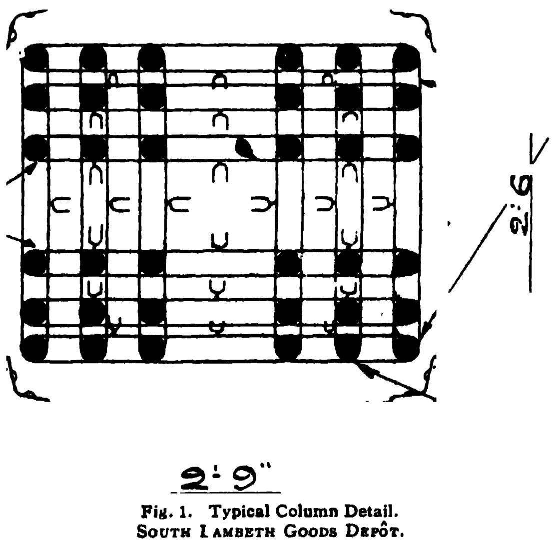


Fig. 1. Typical Column Detail.
SOUTH LAMBETH GOODS DEPÔT.

The accommodation provides a basement for storage purposes; a ground floor, which has a height of 36 ft. 4 in. from the level of the railway lines to the first floor level, and three upper floors for the storage of goods, the topmost one being constructed over portions of the building only in the form of three bays,

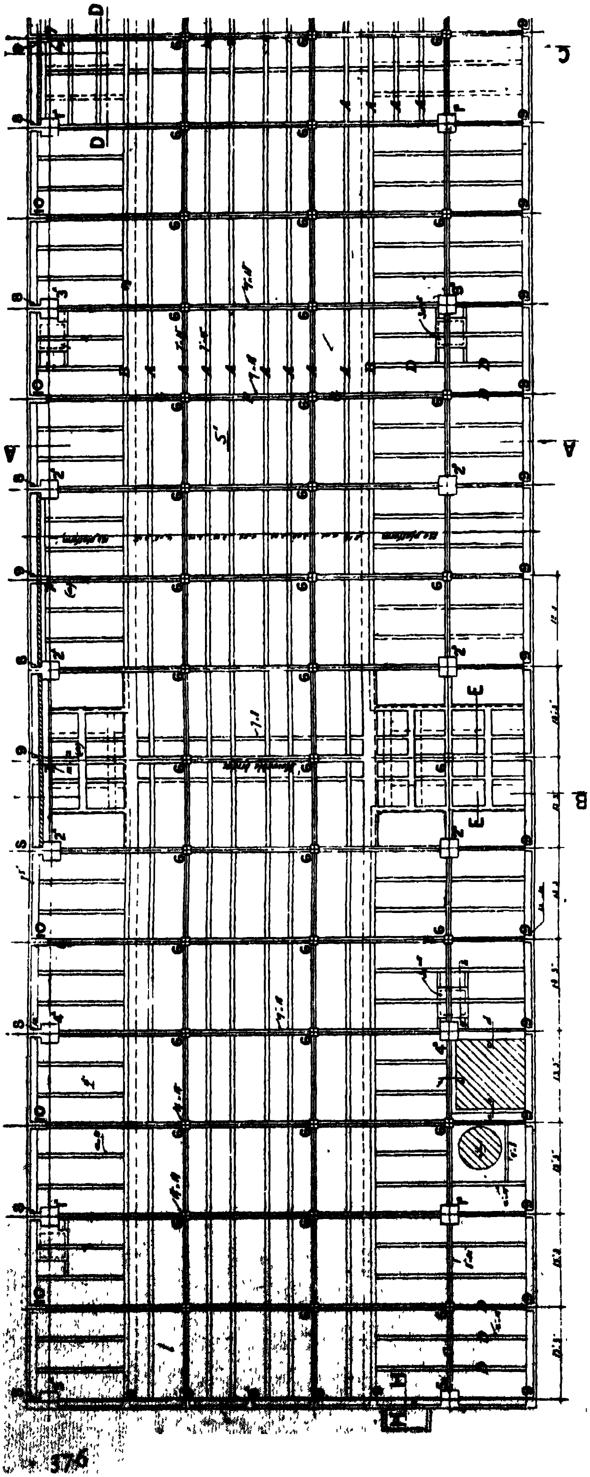


Fig. 2. Plan showing Beams and Columns under Ground Floor.
SOUTH LAMBETH GOODS DEPÔT.

each 72 ft. by 53 ft., thus allowing for a future extension if required. The flat roofs have also been constructed of sufficient strength to carry goods that may be placed upon them, and the storage area is therefore very extensive.

The building is constructed as a reinforced concrete frame building, all the weight-carrying members being of this material, and the external walls themselves, which are of brickwork, are carried by reinforced concrete beams. The basement floor is about 2 ft. 6 in. above the underground water level, and the underside of the column bases is 4 ft. below the basement floor level, or 1 ft. 6 in. below the water level. The basement floor is surrounded by reinforced concrete retaining walls, which are protected with clay puddle to prevent the percolation of water, these walls having a height of about 13 ft. or 15 ft., and being constructed 5 in. thick, well reinforced in all directions and stiffened with counterforts 12 in. square at intervals.

The foundation to the wall consists of a projecting toe 8 in. thick and 3 ft. in width, with bars in both upper and lower surfaces. A hori-

zontal beam is formed at the top of the wall to carry the ends of the beams supporting the platforms, and this is about 18 in. square. The foundations to the columns were generally of two sizes—viz., about 12 ft. to 14 ft. square for the main columns, which extended through the ground floor to carry the main loads of the building, and about 6 ft. by 2 ft. 6 in. for the remaining columns, which occurred for the height of the basement floor only.

The type of base adopted consisted of a slab having a minimum thickness of 7 in. to 11 in. splayed up towards the column to give a maximum thickness at the intersection of from 21 in. to 44 in. to provide the requisite shearing area. The reinforcement consisted of two sets of rods, each set having bars in both directions, and these were connected to each other and the mass of concrete in the base by numerous stirrups, with additional distribution bars at the bottom of the vertical reinforcement to the column. The whole of the bases were designed to give a uniform pressure per square foot on the soil to prevent the possibility of unequal settlement.

The arrangement of the columns is interesting, as will be seen from the half plan of the ground floor construction (viewed from below), which is illustrated in *Fig.* 2. The smaller columns shown are those which occur on the basement floor only, and these are spaced in three longitudinal rows in the interior at distances apart equal to 13 ft. 3 in., while there are only two rows of main columns, and these are spaced at 26 ft. 6 in. centres. The width between these latter columns is about 58 ft., and they carry the whole of the superstructure, thus bringing a large load upon each one. The section employed is 2 ft. 9 in. by 2 ft. 6 in. at the basement level and there are no less than 36 bars used as the vertical reinforcement for each column, these being arranged in four groups of nine bars situated at the corners, and connected by steel links in all directions, as shown in *Fig.* 1. These columns are reduced to 2 ft. 9 in. by 2 ft. 3 in. at the ground floor level, with a further reduction to 16 in. sq. on the first floor, and they are protected with steel sheathing attached to angle steels at the corners to prevent damage when knocked by heavy goods. The smaller columns in the basement are 14 in. square in section and reinforced by 4 lines of vertical reinforcement, with steel links at intervals. The spacing of the beams at the ground floor level is shown on the plan mentioned previously and these consist of main and secondary beams.

The tracks between the platforms are carried by secondary beams, four being placed under the rails, and these are about 1 ft. 7 in. deep and 7 in. wide, and all four beams are connected to and carried by main beams which are 1 ft. 11 in. deep, 9 in. wide, and span between the columns at 13 ft. 3 in. centres. The slabs filling in the panels are 5 in. thick, and this is included in the depth of the beams as given; while haunches 12 in. deep and 2 ft. long are provided on the main beams at the junction with the columns. The distance between the platforms is 32 ft. 7½ in. and these have widths of 16 ft. and 25 ft. respectively, the former having a projection of 2 ft. beyond the line of the main columns and the latter having a projection of 12 feet.

Apart from the variations necessitated by staircases and weighing machines, etc., these platforms are carried by beams at the inner edge, beams between the

columns and the beams at the top of the retaining wall on the outer edge, together with smaller transverse beams supported on these spaced at 4 ft. 5 in.

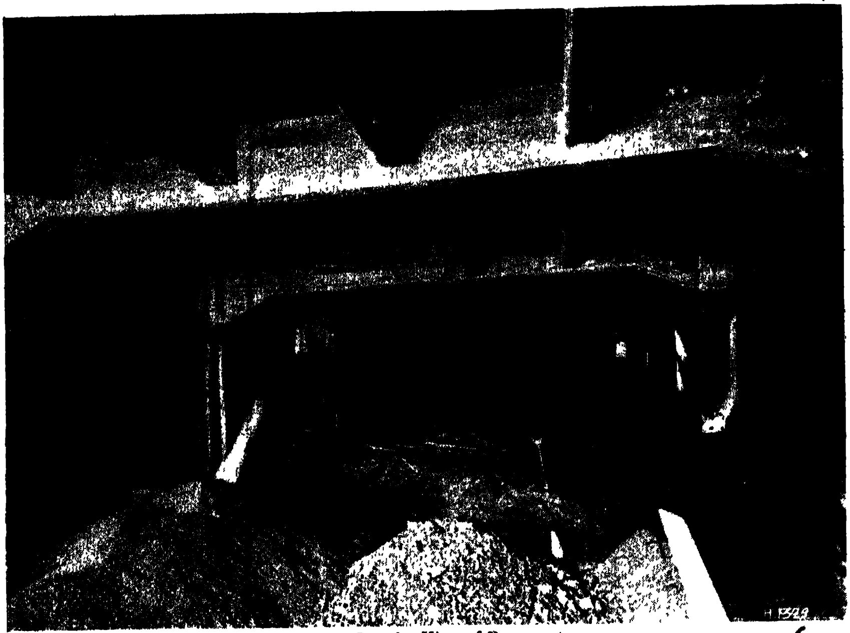


Fig. 3. Interior View of Basement.

Fig. 4. View during Construction.
South Lambeth Goods Depôt.

centres. The platforms are all 4 in. thick, and the outer edges of the platforms on the roadway side are protected by heavy cast-iron curbs. A view

Fig. 5. Reinforcement for Large Beam in Position.

Fig. 6. Interior View of Goods Station.
SOUTH LAMBETH GOODS DEPÔT.

showing the basement floor during construction is illustrated in *Fig.* 3, where the main and secondary beams, together with the metal sheathing to the columns, can be clearly seen. The work to the platforms, etc., can also be seen in the photograph taken during construction and illustrated in *Fig.* 4.

The floors above the ground floor are constructed to carry an external load

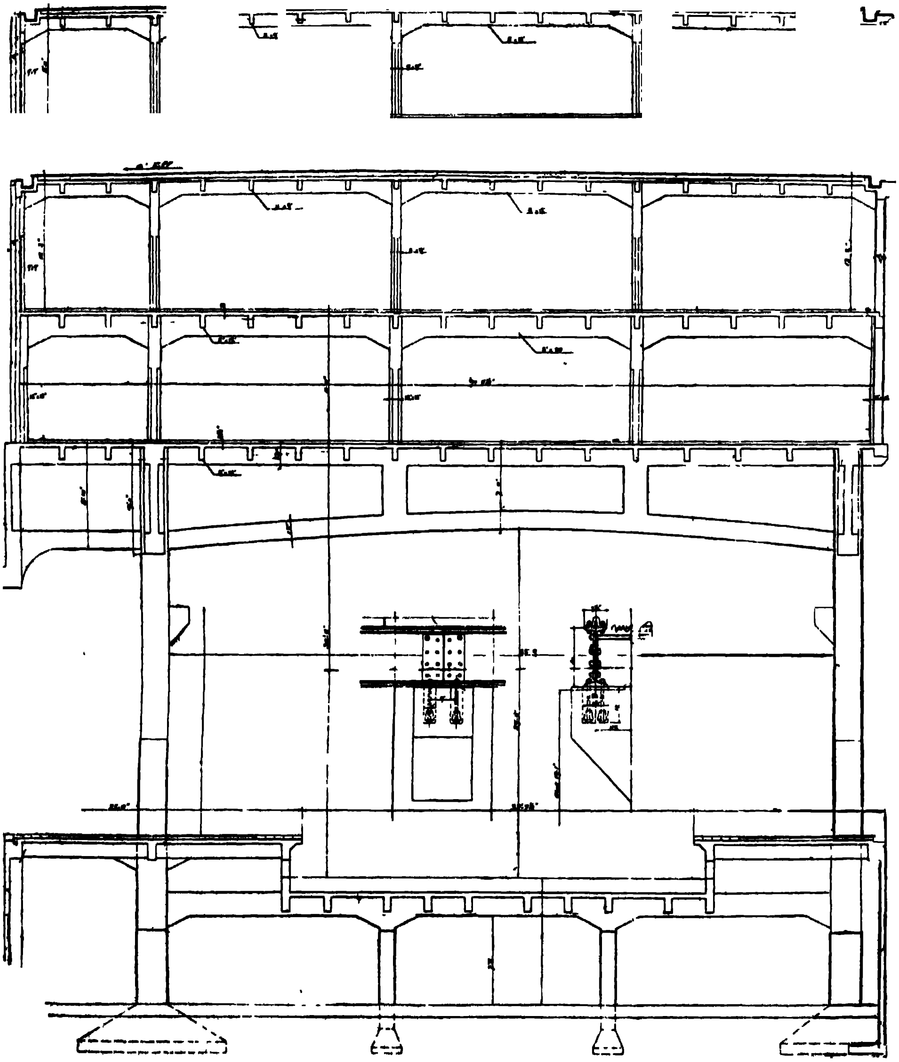


Fig. 7. Cross Section of Goods Station.
SOUTH LAMBETH GOODS DEPÔT.

of 3 cwt. per ft. super, and here the secondary beams are spaced at 4 ft. centres and the filling is $3\frac{1}{2}$ in. thick.

The most interesting features are the large main arched beams which occur at the first floor level and span transversely across the station between the main columns and cantilever a distance of 12 ft. 9 in. beyond the

line of these columns at the southern end. These beams are certainly some of the longest constructed in reinforced concrete, the total length being about 72 ft., and their great advantage will be apparent, as there are five rows of columns on the upper floors, two of which are carried by cantilever projections, one continued up from the line of the main columns and two supported by the central span of the beam. It would have been inconvenient and inadvisable to continue all these columns through the ground floor, and by the method adopted the columns were reduced to two lines only. The beams are arched and have a depth at the centre of 7 ft., and 8 ft. 9 in. at the junction with the columns, inclusive of the thickness of the floor slab, and the width is 2 ft. In order to reduce the dead weight and improve the interior appearance of the station the thickness of the web is reduced to form four panels, each 9 in. thick with stiffeners 2 ft. wide between same. The beam therefore becomes practically a flanged section, the tension flange, which is arched, being 2 ft. by 1 ft. 6 in., and the compression flange 2 ft. by 1 ft. 9 in. A drawing of this beam is illustrated in *Fig.* 9, and it will be seen that the reinforcement consisted of no less than eighteen bars in the compression area and twenty bars in the tension area, with numerous links for connecting the bars and stirrups for resisting the shear. Some of the shuttering with the reinforcement in position is shown in the photographic view illustrated in *Fig.* 5; but it was impossible to obtain a view showing the whole of the steelwork in position owing to the obstruction of the woodwork.

Longitudinal beams 9 ft. 3 in. deep and 1 ft. 8 in. wide are also constructed between the main columns and at the outer end of the cantilevered portions, thus tying the whole construction together and forming a rigid structure. These beams also have the webs reduced in thickness to 10 in. to lessen the dead weight to be carried. This building is quite unique and gives an excellent idea of the possibilities of reinforced concrete, the whole of the upper part being carried on the few main columns and projecting beyond these on either side, giving a curious effect, as will be seen in the section illustrated in *Fig.* 7. A general view of the structure when practically finished is shown in *Fig.* 8, and some idea of the length can be gathered from this.

The western end of the station is filled in with galvanised iron carried by steel framing, with the necessary opening for the passage of the trains. At the south side of the building the van roads and railway tracks are covered by steel-framed roofing, 48 ft. wide, for protection against the weather, and the steelwork is connected to the reinforced concrete work with Lewis and rag bolts, and in some cases reinforced concrete wall plates are utilised to carry the ends of the trusses. In addition to the goods station herein described, reinforced concrete was employed for the columns, floors and staircases throughout the office building, which is about 83 ft. long by 41 ft. wide, and consists of basement, ground, first and second floors, and also in the stable building, which is designed with an L-shaped plan, the main portion of which is 136 ft. long and 28 ft. wide, and the secondary portion 54 ft. long by 28 ft. wide. The latter has a special covered sloping way for the traffic of horses to the upper floor, which is designed to carry an external load of 1½ cwt. per sq. ft. This sloping way is supported on reinforced concrete columns spaced at 13 ft. 3 in. centres, and the floor and roof beams and slabs are constructed with similar material.

The whole scheme is a most complete one, and adequate equipment is provided in the station for the hauling of trucks and hoisting of goods, the cranes being carried in some cases by brackets which project from the main columns, and two movable bridges are provided for the transfer of goods from

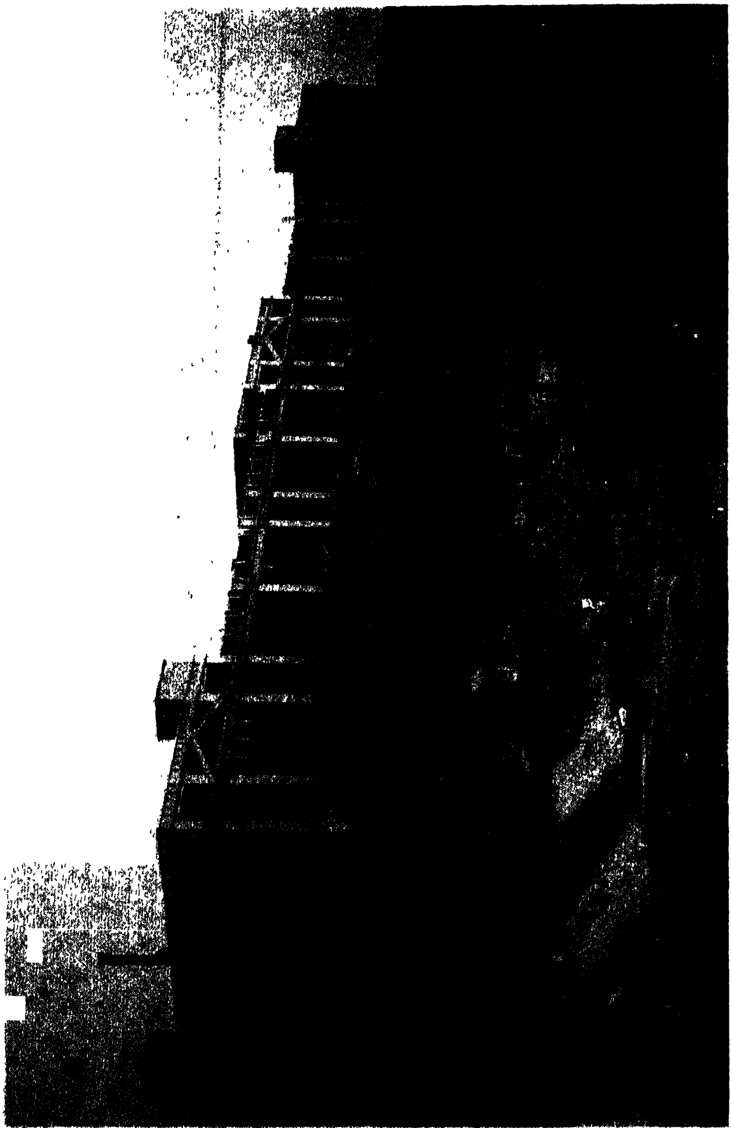


Fig. 8. View of Buildings practically completed. SOUTH LAMBETH GOODS DEPÔT.

one platform to the other, these being similar to those which have been in use for many years at Paddington Station.

The contractor for the work was Mr. A. N. Coles, Plymouth.

CRACKS IN CONCRETE AND SURFACE TREATMENT BEING TWO REPORTS OF THE REINFORCED CONCRETE PRACTICE STANDING COMMITTEE OF THE CONCRETE INSTITUTE.

We present herewith the two following reports recently issued by the Concrete Institute on the very important questions of "Cracks in Concrete" and the "Surface Treatment of Concrete." An interesting discussion followed, of which we are only able to give the barest outline, but, as mentioned in the report of that discussion, we earnestly hope the Sub-Committee responsible for these reports will take heed of the various criticisms and suggestions thrown out, for excellent as the reports are in many ways, they require considerable amendment and elucidation before they are finally approved by the Council.—ED.

In June, 1909, the Reinforced Concrete Practice Standing Committee of the Concrete Institute issued letters of inquiry to all the members of the Institute in order to obtain information concerning Cracks in Concrete and the Surface Treatment of Concrete. In reply to these inquiries some fifty-four letters were received regarding the Cracking of Concrete and forty-six letters regarding the Surface Treatment of Concrete.

The Reinforced Concrete Practice Standing Committee have now issued two reports setting out a review of the subject, together with recommendations. These reports were read at the Institute's thirty-sixth ordinary general meeting, followed by a short discussion. They read as follows :—

REPORT ON CRACKS IN CONCRETE.

The cracking of concrete is unsightly, but is not necessarily dangerous. Cracks in concrete may be divided into two classes :—

1. Surface cracking.
2. Body cracking.

In the first category the cracks are often referred to as "hair" cracks, by reason of their fineness and semblance to hairs, and occur both in plain and reinforced concrete. They are also known as "crazing" and are of very frequent occurrence. They appear to arise from the surface skin of cement mortar being richer in cement than the mortar of the body concrete, thus exposing almost a neat cement skin, which expands at a different rate on exposure to the sun's rays than the body concrete. It is worse upon the uppermost face in a mould, where the lighter and weaker particles of cement work up to the top and form a skin known as "laitance." If work be kept under water, and sometimes, if shielded from the sun, this crazing may not occur. To overcome its unsightliness the surface skin should be removed either (1) by brushing the concrete when green with wire brushes; (2) by rubbing by means of a stone or piece of concrete and sand and water; (3) by dressing with hand or pneumatic operated chisels and hammers; (4) by brushing the surface with hydrochloric acid and subsequent washing with clean water. The last two named methods are best with completely hardened concrete.

The cracks extending through the body of concrete may be ascribed to the following :—

1. Faulty design and construction so far as statical resistance is concerned.
2. Expansion of cement or concrete.
3. Corrosion of embedded steel.
4. Shrinkage from setting and hardening in air.
5. Difference of temperature in different parts.

1. Under the first head the following causes have been noted :—

(*a*) Settlement of the foundations.

(*b*) Too high a stress in the reinforcement, resulting in excessive deformation.

(*c*) Too thick a covering of concrete, in particular where the effective depth of beams is very small.

(*d*) Too early removal of forms. The age of the concrete when the forms are removed must be sufficient to give the usual factor of safety due to the stresses caused by dead load and such accidental load as may at that time be anticipated. Generally the following recommendations are made, subject to the approval of the engineer or architect responsible for the works.

For mass concrete walls not subject to thrust, and where the height does not exceed 2 ft., the forms should not be removed under 24 hours. Where the wall is subjected to pressure, forms should remain in place at least a week, although a fortnight is preferable. For mass concrete arches of more than 20 ft. span one month is recommended.

For reinforced concrete the following is recommended :—

Slabs, a minimum of 7 days, but otherwise, for slabs carrying only their own weight, an allowance of 2 days per inch of thickness, or 1 day per foot of span, whichever is the greater. For sides of beams, walls, and columns not under side-thrust a minimum of 4 days; bottoms of beams, a minimum of 2 weeks, though a month to 6 weeks may be necessary under special circumstances; for arches the time of removal of the centering is better left to the judgment of the engineer, keeping in view the ratio of rise to span and special circumstances.

If it is intended that the structure should be used for carrying heavy weights, emergency props should be left in for such time as the engineer or architect may direct.

The foregoing periods to be increased by at least the time during which frost or rain has intervened.

(*e*) Defective design of forms with inadequate allowance for contraction and expansion due to variation of moisture. Dry timber may expand and crack the concrete unless wetted beforehand.

(*f*) Careless removal of forms, which may result in cracking the concrete by shock of falling timber, or by levering and prising on the green concrete.

(*g*) Vibration, resulting in deficient adhesion and excessive deflection. Forms should be very rigid.

(*h*) Insufficient allowance for continuity, fixity, and general monolithic nature of concrete work done *in situ*. Over supports the maximum degree of continuity and fixity should be provided for. Frequently cracks will be found over supports of continuous reinforced concrete beams and floor slabs, owing to the omission or insufficiency of steel there. Concrete floors are often built in chases in walls and carried over walls, others standing above, and sufficient fixity is given to cause cracks, if provision has not been made in the reinforcing. Columns and piers when built monolithic with beams will give more or less fixity to end of beams resting thereon, both at end and intermediate supports.

(*i*) Too close spacing of steel, so that there is no room for the concrete to get round and adhere or bond with the bars.

2. Expansion of cement or concrete.

Under this heading the following causes of cracking are noted :—

(*a*) Overlimed and coarsely ground cements which were frequently met with years ago caused expansion, to overcome which it was necessary to leave room for expansion—*i.e.*, expansion joints. Especially was this precaution adopted round the edges of floor slabs adjoining walls.

(*b*) Coarse materials containing sulphur compounds, unburnt fuel, oxidisable or hydratable iron compounds, unslaked lime, and other deleterious substances. Breeze, clinker, and slag frequently contain sulphur and metallic iron or oxide of iron, while boiler ashes may contain both sulphur and unslaked lime (the latter derived from limestone in the coal). Some bricks contain

sulphides and sulphates and lime, and should not be used broken for concrete. Old bricks also sometimes have old plaster adhering to them; the sulphate of lime may cause no trouble in plain concrete while it is kept dry, but in the presence of water reacts chemically with the aluminates of the Portland cement, forming sulpho-aluminate of lime, which is attended by increase in volume, and may cause blowing if in large quantity, and even a small quantity may result in cracking. Free lime in the same way will swell or contract with water. Black magnetic oxide of iron will become converted into hydroxide of iron in the presence of moisture. Indeed, any iron compounds are dangerous in reinforced concrete as likely to react electrolytically with the steel in the presence of moist air or dampness, and sulphur causes speedy corrosion.

3. Corrosion of embedded steel.

Should the steel in reinforced concrete corrode by reason of porosity of the concrete or the presence of deleterious substances in the coarse materials of which it is made, or by electrolytic action, the concrete cover to the bars will crack and burst off.

4. Shrinkage from setting and hardening in air.

This is probably the most frequent cause of cracking.

Concrete will expand slightly in water and contract on drying out, so that cracking is frequently not evidenced from this cause until the concrete is allowed to dry, varying usually up to two months, and in thick mass walls moisture and heat are retained for a long period and may delay cracking up to six months and even longer. It is usual to keep concrete wet for several days after manufacture in order to ensure its gaining maximum hardness, and it is specially important to prevent rapid drying by sun and wind, so that the surface of concrete should be shielded against such exposure. A dry mixture of concrete shrinks less than a wet mixture, and concretes richer in cement contract more than lean mixtures. For reinforced concrete work medium wet mixtures are desirable, and therefore concrete richer in cement than 1 to 5 is not advisable for curtain walls. The coefficient of contraction of concrete on exposure to air appears to be about 0·0002 to 0·0005 at one month, and increases to about 0·0004 to 0·0006 at 1½ years. The variation recorded is between poor and rich concretes. Such contraction is usually prevented from taking place uniformly throughout; in retaining walls and pavings it is prevented by friction of the soil, in other cases by the holding of other parts. Plain concrete will usually hold together for some distance, so that contraction joints need only be inserted at intervals; the following are advised as suitable distances apart of such joints in plain concrete :—

Paving, 4 to 5 ft.
Curtain walls, 10 ft.
Exposed retaining walls, 15 to 20 ft.
Basement retaining walls (not exposed) and dock walls or dams, 50 ft.

If curtain walls adjoin heavy columns and beams, the rigidity of the latter would probably result in cracking if constructed monolithically, even if reinforced. It is best, therefore, in such cases to provide joints adjoining beams and columns.

If concrete be laid over the joints of a thicker lower surface of concrete, the joints of the latter will most probably be evidenced in the upper surface.

Sharp angles in structural members have little resistance, and should be avoided, as also irregular shapes. The angles of window openings, unless well rounded, should be reinforced by bars placed diagonally.

As the rate of shrinkage varies with different proportions of the concrete ingredients —cement, sand, coarse material, and water—variation in such proportions should be avoided as much as possible. Cracks in plastering are often due to such irregular contraction.

Partition and wall blocks, if required to be plastered soon after laying, should be quite dry before laying. If erected wet, the plaster should not be applied until they have had good time to shrink, otherwise the joints of the blocks will show as cracks in the plaster.

Large surfaces have been successfully constructed without apparent cracks by properly reinforcing the concrete and laying all at one operation. The object of the reinforcement is to break down the tensile resistance of the concrete and cause it to crack uniformly at such close distances as to render the cracks invisible to the eye.

If one portion of the concrete be left overnight, great care should be taken to roughen the hardened surface by tooling away; then clean by brushing with water, and apply half an inch of mortar of the same proportion as the mortar in the concrete and ram the fresh concrete well against it. Such joints will often show, even though well reinforced. In calculating the amount of reinforcement for such purpose, the ultimate tensile strength of the concrete at one month should be equated to the resistance of the steel at the yield point. Usually for a 1 : 2 : 4 concrete ½ per cent. of steel is required each way, the bars or meshwork being laid at right angles. The reinforcement should be in small sections and well disseminated through the thickness of concrete, and a layer of bars should be near each face. So-called "distribution bars" near the bottom of floor slabs are not sufficient if cracking is to be resisted; rods should also be placed near the upper surface. Cracks frequently occur parallel to rods where "distribution bars" are not used, and also occur at right angles to main bars where continuity bars stop; top reinforcement would avoid this. Contraction reinforcement should be in addition to the section of steel required to resist static forces.

The sudden drying out when heating apparatus is installed frequently causes excessive cracking.

5. Difference of temperature in different parts.

Considerable difference of temperature will cause cracking and should be avoided as much as possible. Heavy reinforcement is not always an effectual preventative. Most reinforced concrete chimneys in which the internal temperature is over 500° F. seem to be cracked vertically, externally, and often horizontally as well, though possibly the latter could be avoided. This cracking is probably due to the difference in temperature between the outside and the inside, which may be considerable with a cold wind blowing. A continuous lining with cavity between it and the outer shell would probably prevent serious cracking.

Great difference in the temperature between the underside and top of concrete floors is also likely to cause serious cracking. In some climates the variation in temperature is extreme and cracks will result, and even if reinforcement is provided it will be well to insert expansion and contraction joints every 50 ft.

Concrete lining, and walls of ponds, tanks and the like exposed to water do not shrink by setting and hardening of the concrete, but change of temperature between summer and winter will cause cracks unless joints are provided. If plain concrete, a joint every 15 ft. is desirable; if reinforced, joints might be 50 ft. apart, though closer is preferable. To prevent percolation, asphalt dowels in the joints have proved efficient.

REPORT ON SURFACE TREATMENT OF CONCRETE.

(Summary of Replies Received.)

1. Rough-casting is the best finishing coat for exterior finish. In applying a cement rough-cast, however, a bonding material should be used to insure adhesion to the old concrete. For floors, stairs, walls, and internal finish generally, tiles and granite finish may be employed; there, also, the use of a bonding material is advocated.

2. Blue stone dust trowelled to a glass face before the cement is set is advocated for facing the concrete, without any rendering. For rendering mortar composed of 1 part of sand to 1 part of pure Portland cement is advocated with trowelled finish.

3. In surfacing the concrete without rendering it is advised that the surface of the mass concrete should be beaten down level and smoothed with a wooden or metal float just as it is beginning to set according as to whether a dead or bright surface is desired. It should never be faced, as is often done, by the application of a thin skin of a finer material, which, when applied if the mass has partly or wholly set, nearly always comes off. Micaceous, clayey, silty, or ochreous sand or gravel should be avoided, particularly micaceous sand, the mica in which, if the concrete be much worked, rises to the surface and causes constant dusting. If a floor is to be faced with a finer or richer class of concrete, then use that used for the body. The best results are obtained by laying the body and face at the same time, the facing portion being laid on the top before it has set and being well beaten down into it. Exposed concrete faces should never be much wrought or polished with a metal tool, as the resulting dense smooth skin invariably develops hair cracks, which are unsightly. In moulded work the face

next to the mould may be made of finer material if the concrete is mixed very dry and the facing material be made soft and the dry concrete, before ramming, be held back with a shovel placed between it and the mould; the subsequent ramming will cause this face to unite with the body. If a facing material is not used, the concrete should be mixed plastic and worked up and down and to and fro with a shovel, trowel, or rod all along the faces which are to be exposed, and particularly along the arrises. Concrete for such work requires to be properly proportioned so as to be without voids. On removal of the forms any roughness may be removed by rubbing with a piece of sandstone and water, or the face may be rubbed with a mixture of sand and cement by means of a wooden float, but this latter is not recommended if oil or soap has been used on the moulds, as the thin skin frequently fails to adhere and weathers off. If rendering is employed, Portland cement or clean gritty sand or fine gravel is the best; the cement should be so proportioned as to rather more than fill the voids in the aggregate. It is not desirable to render with neat cement, as hair cracks generally ensue. The surface to which the rendering is applied should be as rough as possible, quite clean and free from grease, mud, or dust, and, if necessary, it should be washed with a hard-bristled brush. If at all of a porous character, the surface should be saturated with water before the rendering is applied. Portland cement rendering should never be applied to surfaces of materials containing sulphates; in one case a floor made of plaster rubbish and hydraulic lime was covered with an inch of excellent Portland cement rendering which parted from the floor wherever patches of plaster had come to the surface of the body. In another case rendering was applied over a rough coat of plaster-of-Paris, and all came off in large sheets. For colouring concrete or rendering care is necessary in selecting colours; Venetian red and Indian red should never be used, as they are always in practice heavily loaded with calcium sulphate, which often causes the cement to disintegrate. Red hæmatite, some red ochres, and many other of the iron ores, particularly if burnt, are safe and suitable. Red hæmatite has a very powerful effect, very little being needed. Yellow ochres are suitable and safe, and have considerable colouring power. Burnt umber is safe, and gives a nice warm colour. A satisfactory colour has not been found in blue or green; copper arsenide gives a fair green, but it is not desirable. Ultramarine is unsafe. Black oxide of manganese is probably best, but it is not possible to get a clear black. Ground hard-burnt coke may be used, but it is not so good. Ground coal or lamp black is quite inadmissible, except in the case of some of the anthracite coals. A clean white is not obtainable, but a near approach may be made by using slaked white lime; the lime carbonates on the surface and forms a permanent, almost white, colour. A cream colour which looks very well may be obtained by using slaked lime with a little yellow ochre- chalk and whiting do not give very satisfactory results. In all cases but that in which slaked lime is used, the colour in sufficient quantity to give the desired tint should be mixed (preferably ground) with the dry cement. Hand mixing is not satisfactory. In the case of slaked white lime, this should be freshly made, but perfectly slaked, and should be mixed with the cement and aggregate at the time of using. By blending the colours named, all usual building material shades of red, brown, buff, and grey may be obtained, and they are all permanent and safe.

4. A facing mixture, usually two parts of sand to one of cement, put in the mould against the face of the form with the concrete behind it, has been found satisfactory. For colouring such a facing ochres have been found satisfactory, especially if used in excess; they have apparently little effect on the durability, and with a white cement a little colour goes a long way. Greys of all shades can be obtained by admixture of lamp black. All the colours seem to fade until the work is matured, but afterwards stand perfectly well. The ultimate colour can always be found by experiment.

5. A good sound skin can be obtained by specially tamping the concrete against the shuttering. All seams or joints between successive lifts require special attention: (*a*) to break the old hard surface of the previous lift; (*b*) to make a good bond or bed of wet mortar between the old layer and the new into which bed the new concrete can settle; and (*c*) to ensure the rigidity of the shuttering across the joint so as to prevent movement and consequent "lipping." If the surface be pitted with small air-holes, a mixture of fine sharp sand and cement proportioned 2 : 1 should be applied with a large brush and immediately rubbed into the surface with steel trowels or floats. The rubbing should be done with energy and continued until the holes are completely

filled and all superfluous plaster rubbed off, leaving the old skin exposed. In this way the holes or pores will be completely filled and the skin watertight, and disintegration under the influence of frost prevented, while at the same time it is not noticeable after the work becomes hard. The principal item of cost other than labour is the number of steel trowels used up. The final surface, it should be particularly noted, is not a plastered skin.

6. If rendering be used, it should be proportioned 2 of sand or very fine aggregate to 1 of cement; in no case should neat cement be used. The rendering should be applied to the mass of concrete as soon as the shuttering has been removed and before the surface has become hard set or carbonated by exposure to the atmosphere. Facing the concrete without rendering is advisable. For colouring, the following materials may be used: peroxide of iron, manganese dioxide, ultramarine, anhydrous chromium oxide, red ochre, yellow ochre, Chinese red, and crimson lake.

7. The most satisfactory way of facing concrete *in situ* without rendering is to apply a plaster in the form of cement mortar against the shuttering, as the concrete is put in, keeping the plaster a little higher than the concrete and carefully working the latter into the mortar all in one operation. For rendering 1 : 1 sand and cement mortar has been found satisfactory. Rendering undoubtedly gives a better appearance, but it very often fails, mostly through frost. Good colour effects have been produced by a sort of stucco, stones being placed by hand in the soft rendering, but such work, to be durable, has to be performed slowly, and is, therefore, costly. The ordinary method, called "slapdash," is not considered durable.

8. It is preferable not to render at all, but to work the concrete against the moulds; for very superior work stout iron moulds, highly polished and perfectly true, are advocated. For colouring, metallic colours such as red oxide are preferred to such substances as red ochre.

9. The use of shell sand makes a pretty finish, but this cannot be obtained everywhere; in Jamaica the sea beach is strewn with broken shell which looks like sand at first sight. For appearance coarse sand is preferable. Buildings tooled all over have a good appearance. The finish might be obtained by pneumatic chiselling or even carborundum wheels. The application of a face of ½ in. of 2 : 1 mortar the same time as the bulk of the concrete is put in behind is advocated. For rendering 2 : 1 mortar with about 5 per cent. of clay in the sand is satisfactory. Rendering should be applied as soon as the moulds can be removed. In the case of bridge work, where the concrete is set before the laggings can be removed, the concrete should be kept wet for an hour or so before rendering.

Black lead applied to the face of the concrete immediately it is in position will render the concrete when set practically indistinguishable from blue Staffordshire bricks.

10. Rough-cast may be advantageously used, tinted or otherwise.

11. For residential or street architecture cement finish is best, and can be varied almost to any extent by polished finish, wood float finish, coarse or fine sand, white sand, red sand, yellow sand; further there is the scagliola finish, but it is, of course, very expensive; the cement can also be tinted a brick red and jointed, and a brick finish obtained. Two to one of sand and Portland cement is best for rendering. The cement should be plastered in the ordinary way but with greater pressure than for ordinary plaster, indeed, the more pressure the better. The best form of colouring should be coloured sand.

12. For rendering 3 : 1 Portland cement mortar finished with a facing coat of 2 : 1 has been employed.

13. A good effect is obtained by removing the mould as soon as it is safe to do so and brushing vigorously to expose the aggregate, which may be the same throughout the body of the concrete or special aggregate in the facing only. Good effects are also obtained by using stone dust with the sand for rendering buildings. Render in coats about ¼ in. thick, then trowel. The following coats should be put on as soon as preceding coat has gone off.

14. Brushing the surface of the concrete before it is set to remove the cement skin is advocated.

15. To face concrete without rendering a creamy liquid mixture made of 1 part of Portland cement and ½ a part of white, clean, sharp river sand has been squirted on the

surface through a rose nozzle and applied in two coats, the second coat being put on six hours after the first. A rendering of a plastic mixture of 1 part of Portland cement to ½ a part of clean white river sand pulverized and reduced to a consistency of dust with lime-water has been applied with a trowel. The surface of the concrete work should be thoroughly wetted with lime-water and picked for at least three hours before either the squirting process or rendering process is employed. Stucco plastering work, resembling marble, may be laid in three coats, the colour being obtained by mixing gypsum to lime and certain metallic oxides. Blue is obtained by oxides or carbonate of copper. Grey is obtained by mixing forge ashes; litharge, yellow oxide of lead, green enamel, etc., are also used to colour it. A polished surface has been obtained by rubbing the surface with a fine smoothing stone, washing it now and again, and rubbing with a linen dipped in Tripoli powder and chalk, then with oil and Tripoli powder, lastly oil alone.

16. A good surface may be obtained by working with a spade perforated with holes up and down against the shuttering.

17. Before applying rendering, the walls require to be hacked and well wetted. To avoid cracking, the rendering should be kept damp and protected from the sun and wind for about seven days after execution. A pleasing appearance can be had by dashing on the rendering white or straw-coloured sand composed of sea-shells; white cement and white sand also give an excellent finish. A pleasing and permanent tint can be obtained by a wash of quick-lime coloured with common sulphate of iron or copperas, which gives a light cream to a warm reddish yellow finish.

18. The concrete should be made moderately wet, and well rammed and sliced with long trowels or swords to drive out the air-bubbles and to prevent any voids on the surface. Where a watertight face is desired—for example, in reservoirs or dock work—the shuttering should be coated with 1 : 1 cement mortar, about ¼ in. thick, immediately before the concrete is deposited and the concrete forced into this mortar. Fillets could be arranged on the shuttering in convenient positions to avoid showing breaks in the concrete deposited at different times—*i.e.*, to give a jointed appearance.

19. To face the concrete, the surface before it has become too hard should be rubbed with an old piece of the same material to remove form marks and general lines, and a wash of Portland cement then applied with a lime-wash brush. A mixture of red oxide to cement rendering has been found to retard setting and to tend to destroy adhesion.

20. A good surface may be obtained by building at the same time as the body of the concrete a facing of sand and cement, or, better still, ground Portland cement, or ground sandstone and cement proportioned 4 : 1. The boarding should be removed at the earliest possible moment, and the surface well brushed with a strong wire brush. In time the surface will resemble Portland stone.

21. For rendering 3 parts of washed sand to 1 of cement have been employed mixed with long clean ox-hair. It should be applied in two coats and the surface left from a wooden float.

22. A rendering of 2 parts of granite gravel ⅜ in. to ⅛ in. gauge to 1 of cement is satisfactory, but is better applied before the body of the concrete has set.

23. Rendering may be proportioned 1 : 1 to 1 : 4, but usually it is about 1 : 2.

24. Forms or shuttering may be coated with a lime-wash made of pure lime, slaked with boiling water and applied when hot. Before application a large cupful of linseed-oil or tallow should be added to each pailful of hot lime; this assists in closing the pores of the wood and prevents the adhesion of concrete.

25. In executing concrete wthout rendering, if the boards are planed and covered with thick oil paper the surface is good enough for whitewashing. The best rendering is cement and sand outside and putty and plaster inside.

26. Rubbing down with sand and water while the concrete is still green is advocated. If rendering be employed, Thames sand washed and screened through a $\frac{1}{16}$-in. mesh to 2 parts of Portland cement is a good mixture.

27. Granitic finish is obtained by 2 parts of granite chippings, ¼ in. gauge with a proportion of granite dust, to 1 of Portland cement. For vertical rendering mortar screeds are employed, but for horizontal granitic facings wood screeds are generally employed. Aberdeen or other coloured chippings give a pleasing effect for floors.

28. For country buildings rough-cast or pebble dash of cement and sand, with a small proportion of run lime therein, about an inch thick, after stabbing a straightened

coat of cement and sand with a piece of wood having short nails fixed therein, projecting about ¼ in. and ½ in. apart, the walls whitened or coloured after, is advocated. The cement protects the concrete from drifting rains. Several other processes have been tried with indifferent success. Pieces of wood 4 to 5 in. wide and 1 in. thick fixed to the concrete to represent half-timber work, and cemented between to form panels for a lodge very much exposed to drifting rains was easy to do and answered its purposes —but a sham. Cement and slag from iron ore, crushed and passed through ⅛-in. sieve instead of ordinary sand, proved very successful for rendering. The surface was much harder and the colour more a dark grey, and was preferred to the ordinary cement colour.

29. Rendering is objected to. When appearances have to be studied, a 4½-in. brick wall is built and filled at the back with concrete, a heading course to bind in being built occasionally; by this method expense of shuttering is saved, the concrete being placed after three or four courses of bricks are built.

30. By using waste quartz and mica sand and gravel from china clay preparations if the moulds be quickly removed, and the surface washed with scrubbing-brushes and water, it will have the appearance of white granite.

31. A good appearance can be obtained by removing the moulds quickly and brushing with a wire brush and water; if the concrete has become hard, some dilute hydrochloric acid must be used to remove the cement. If a smooth surface is preferred, the moulds can be removed after the concrete has been deposited, and the surface rubbed over with a wooden float to remove inequalities, after which a thin grout of sand and cement of the same proportions as the mortar in the concrete can be applied with a cork float.

32. For inside a thin skimming coat of 3 parts of sand and 1 part of lime putty, and with 25 per cent. of Portland cement added, has been found satisfactory; for external rendering 1 of cement and 3 of sand is advised.

In the discussion which followed, some interesting points were raised, which we trust will have the careful consideration of the Committee dealing with these questions. In the course of his criticism of the two reports, Mr. Alban N. Scott made reference to the constant use of the word "crazing," which in the first report evidently meant a form of crack, and in the second report was used probably in its more true sense, namely, meaning "flaking off." He also disagreed with the suggestion that concrete should be fairly liquid and the advocacy of bringing the finer particles to the face of the concrete. He showed that according to the first report this latter recommendation caused "crazing" and cracking, and, moreover, he pointed out that it is robbing the concrete, which is actually carrying the weights, of its proper proportion of cement. He further discussed the question of dates for the removal of the centering and moulds. He thought it quite wrong to remove the moulds quickly, in order to obtain a good appearance, as this practically amounted to sacrificing strength and durability to effect. He questioned the dressing of the concrete with hand or pneumatic operated chisels and hammer. He also made suggestions regarding the removal of forms for walls and arches, sides of beams, etc. He pointed out the ambiguous use of the expressions "moist air" and "dampness" in connection with steel, and suggested it should be clearly defined what was meant by them. Finally, he spoke at some length on the question of expansion joints as dealt with in the reports.

Dealing with the report on the Surface Treatment of Concrete, Mr. Percival M. Fraser said he sympathised with the views of a previous speaker, and had hoped more would be said about surface treatment, which means treating the surface after it is there, whereas the Report apparently aimed at putting a surface on, which is not in accord with its title. Nothing is said about weather-proofing the surface. Some recommendations as to how to avoid honeycombing would have been invaluable, as it is a very common fault. Only a passing reference is made to this in the report. The method of obtaining a good surface by working up and down the shuttering with a spade; the application of a mixture of sand and cement to the inside of the moulds were strongly criticised.

One method of obtaining a nice-looking surface to concrete is not mentioned in the

report at all, viz., the application of a good coat of distemper, which should be put on immediately the centering is struck and a further coat should be applied just before leaving the work. It has an extraordinary effect in filling up pores, and any tint can be used. Some buildings have recently been put up in Jamaica and the surface treated in this manner and they looked delightful. No reference is made to the safety of painting concrete, which is an obvious method for finishing off the surface.

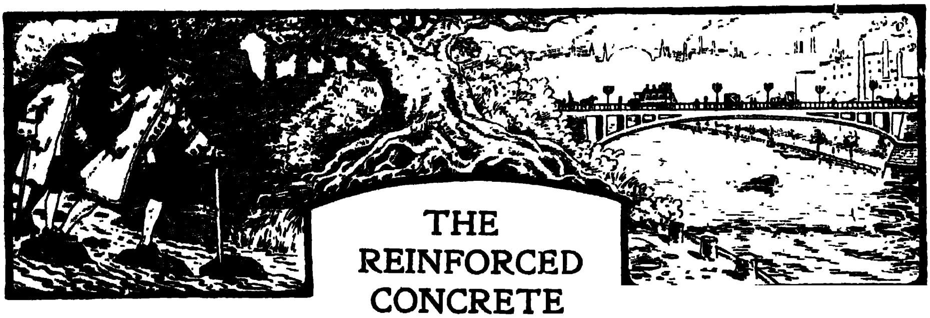
Another speaker said he had been rather hoping that the reports had made some mention of the various patents for rendering the surface of concrete waterproof.

A suggestion as to waterproofing was put forward by Mr. Henry J. Harding, who advocated a really good blue lias lime, thoroughly burned and more thoroughly selected, perfectly divided and mixed in its dry state with Portland cement in a certain proportion—viz., 1 : 3 or 1 : 4 in its hydrated state, which is about 2½ times more than in its caustic state, with 3 or 4 of cement.

The same speaker gave details of some interesting experiments he had made with graded granite chippings.

It was stated by the President that if concrete is properly proportioned and made, it is absolutely impervious to water, and where it is found not to be waterproof it is badly proportioned and badly made with an insufficiency of cement. He also related in some detail his experiences about the striking of the shuttering, and pointed out there were cases where the shuttering had been struck on structures 130 ft. high in 34 hours without detrimental results; on the other hand it is doubtless often advisable to leave it up as long as possible in the case of certain walls. At this point Mr. Alban Scott interposed, and said that even if such be the case, in a report of this kind,—which is probably to be issued to people who are not so conversant with the question,—some cautioning clause should be inserted.

The various criticisms put forward were replied to at length by Mr. Workman, who assured those present that all the suggestions made would receive careful consideration.



THE REINFORCED CONCRETE BRIDGE OVER THE MOLDAU, NEAR THE ISLAND OF ŠTVANICE, WITH SOME HISTORICAL NOTES ON THE OLDER BRIDGES OF PRAGUE.

By F. MENCL,
Engineer-in-Chief, Prague Municipal Commission of Public Ways.
(Translated).

An important bridge has recently been erected in Prague, the form of construction being Reinforced Concrete, and, as much difficulty was encountered in the work, the following particulars of the new bridge, with some historical notes of Prague's older bridges, may not come amiss.—ED.

Historical.

THERE are many bridges in Prague which are of considerable interest. As far back as 1169-71 a bridge was erected in stone 514 m. long. This was one of the first large arched bridges of the Middle Ages. This bridge had but a short existence, for it was washed away and demolished by a flood in 1342, but of its twenty-six arches three have been preserved in the cellars of the houses on the bank of the river.

In 1357 King Charles IV. ordered that a new bridge be constructed, and this now bears his name. This bridge consists of sixteen arches, and it, too, suffered several times through floods, as its foundations lacked depth, but it has always been kept in repair. On the last occasion on which it was restored, after the flood of 1890, the repairs cost nearly 2,500,000 francs. (*For illustration see page* 401.)

The three Gothic towers which are to be found at either end of the bridge, and the double row of statues of the "Baroque" period which decorate its parapets, form some of the most remarkable monuments of Prague.

Until the nineteenth century the Charles IV. bridge was the principal bridge in Prague. It was not until 1846-50 that Negrelli, a Swiss engineer, executed the double-way viaduct, of 1,100 m. in length, which connects the State railway station to Holešovice.

In 1868 the suspension bridge, called "Ordish-Lefèvre," was erected with two lateral spans of 50 m. and a central one of 150 m. This was reconstructed in 1897, and the primitive chains were replaced by cables.

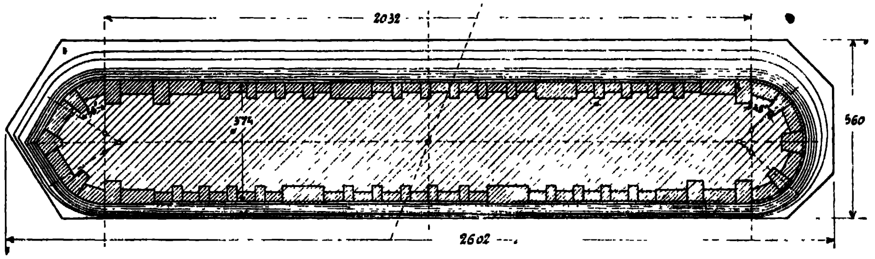
The Palacký bridge, of stone construction (named after the Czech politician and historian), was erected in 1876-78. Its seven arches are from 27 m. to 32 m. wide. Beautiful statues (by Myslbek) decorate its approaches.

The Francis I. bridge, which in 1898-1900 replaced a suspension bridge, has eight stone arches with a maximum width of 42 m.; it is 340 m. long and 16 m. wide, and the net cost of erection was somewhere about 4,160,000 francs. The form of the arches recalls those of the Alma bridge in Paris.

The railway bridge near Vyšabrad did not improve the district with its three bowstring girders of 72 m., and this type of bridge is not worthy of an ancient capital.

The bridge named after the poet Svatopluk Čech was constructed in 1905-8. It has metal arches with rigid spandrils of 48 m., 53 m., and 59 m. in width.

But sufficient of history, as it is principally the new reinforced concrete bridge near the island of Štvanice which is under review here.

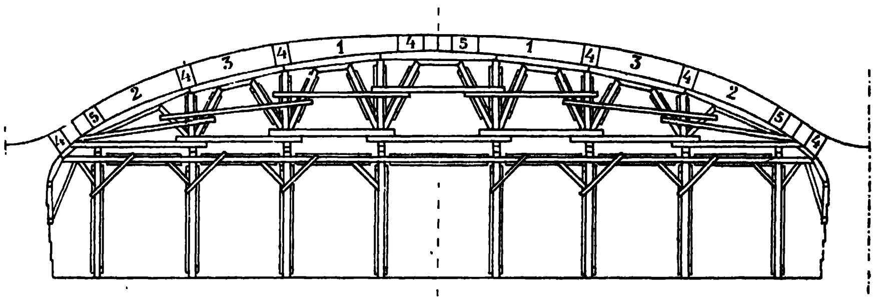


Detail of Pier of Bridge over the River.
REINFORCED CONCRETE BRIDGE OVER THE MOLDAU, PRAGUE.

The New Reinforced Concrete Bridge over the Moldau, Prague.

For a long time a certain amount of prejudice existed in the large cities against reinforced concrete bridges. Where such bridges were built the concrete façades were carefully covered with freestone, as, for example, in the case of the new bridges of Munich and Dresden. Therefore the decision to construct a bridge entirely in concrete in an ancient capital must be looked upon as a new departure.

It must be admitted that the work did not proceed without overcoming some obstacles. Owing to prejudice, one half of this bridge was constructed

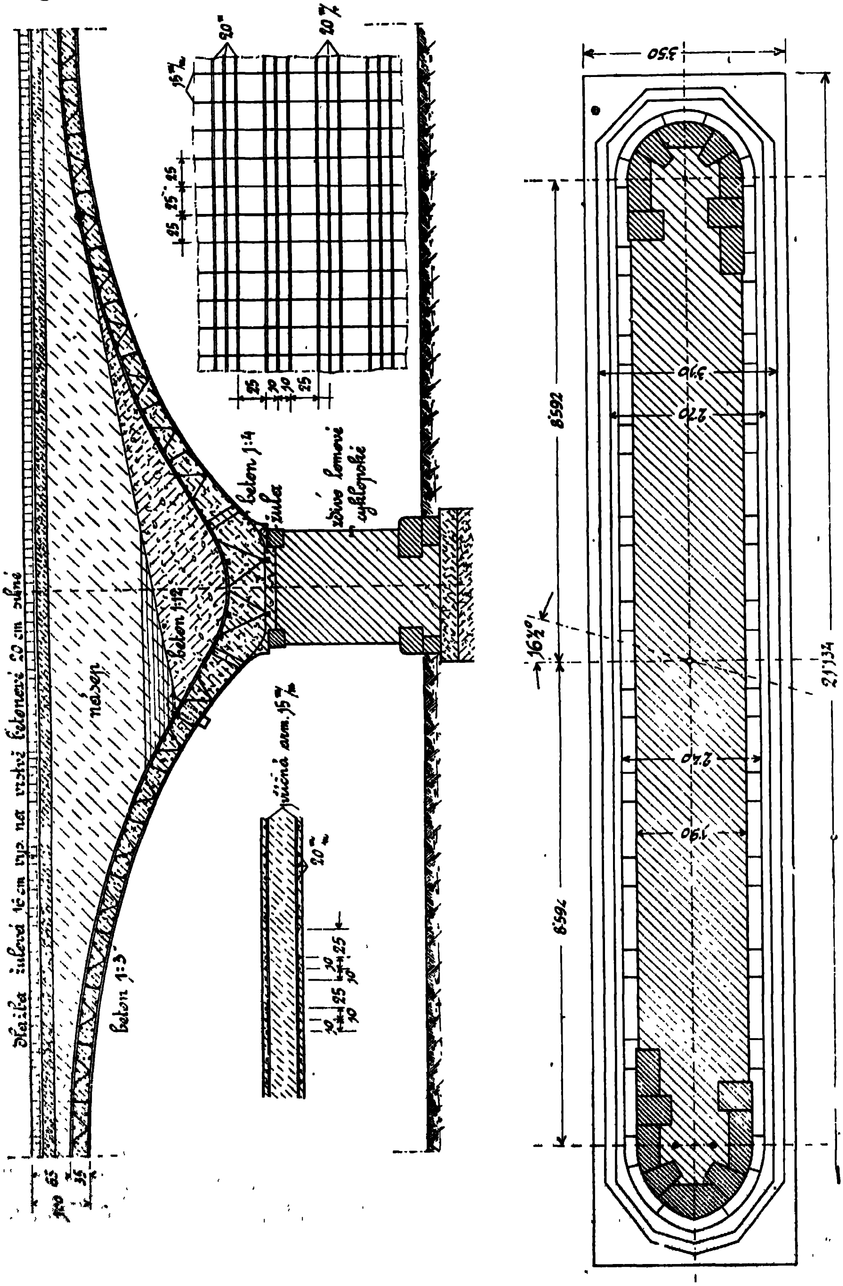


Detail of Arch Centering of Bridge over the River.
REINFORCED CONCRETE BRIDGE OVER THE MOLDAU, PRAGUE.

with metallic arches in 1908-9 (two spans of 46 m.), in spite of the fact that a concrete arch design had been prepared. But the new bridge over the large arm of the Moldau, with its façades made to imitate stone, its balustrades, masts, plastic decoration, and sculpture, was built entirely in concrete.

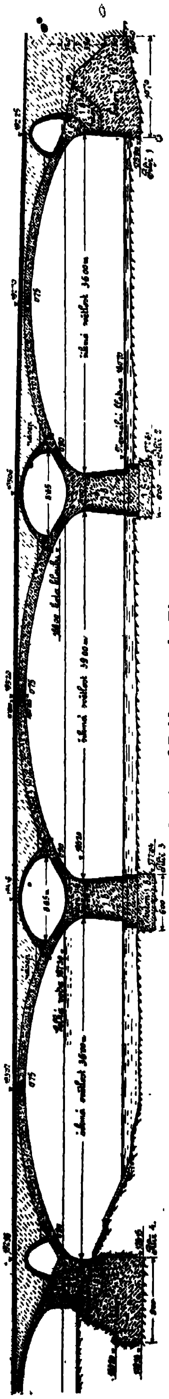
This bridge is divided into two sections: the one traversing the river at a height of about 12·50 m. at low-water mark, and comprising three large arches of 39 and 36 m. span, with an inclination of 69°; the other section, over the

island of Štvanice, is 7 m. high and comprises four small arches 17·85 m. span, the angle of inclination increasing here from 69° to 75°.

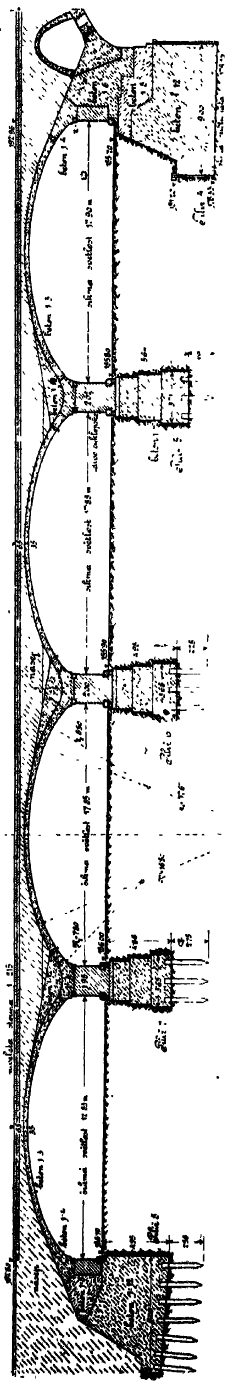


Detail of Pier and Section of Bridge over the Island.
REINFORCED CONCRETE BRIDGE OVER THE MOLDAU, PRAGUE.

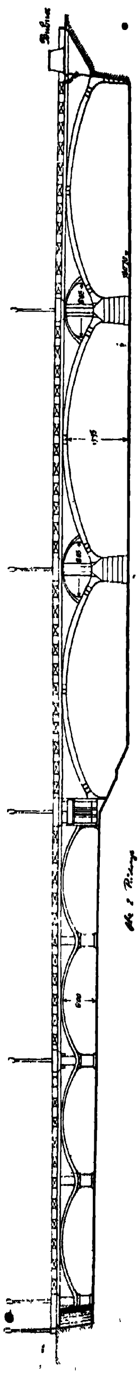
The foundations of the piers and abutments for the large arches were constructed with the aid of dams and direct pumping; the rock is uncovered at the bottom of the river where it is not very deep.



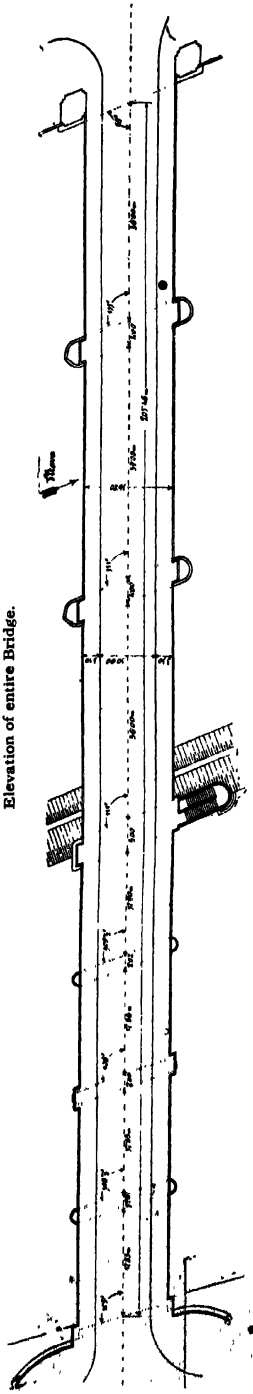
Section of Bridge over the River.



Section of Bridge over the Island.



Elevation of entire Bridge.



Plan of entire Bridge

REINFORCED CONCRETE BRIDGE OVER THE MOLDAU, PRAGUE.

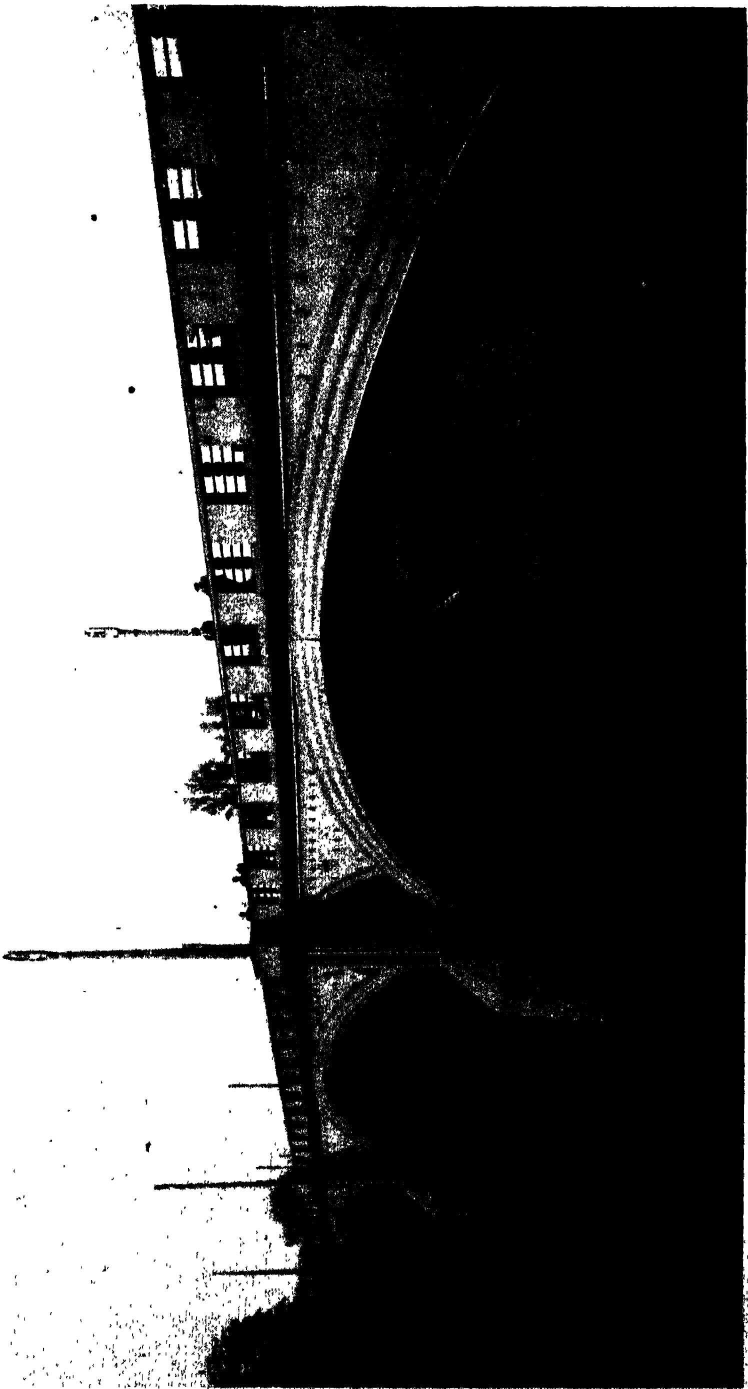
The large arches are of concrete without reinforcement, as there were various prejudices against reinforced concrete, and at Dresden and Munich—towns not far from Prague—large concrete bridges had already been erected without reinforcement. Such bridges very closely resemble stone bridges, and these always inspire confidence among the general public. (A new one at Prague, near Troja, for which the design has also been prepared, is to have a central arch, of 55 m., of reinforced concrete rib construction, which must be considered a decidedly progressive step.)

View showing Bridge in course of construction.
REINFORCED CONCRETE BRIDGE OVER THE MOLDAU, PRAGUE.

The links of the big arches consist of lead plates of 10 mm. thickness, which are 200 mm. wide at the keystone and 240 mm. wide at the abutments; these are inserted between blocks of granite.

The thickness of the arches is 75 cm. at the crown, 90 cm. over the abutments, and 105 cm. at the quarters. The neutral axis of the arches coincides with the curve of pressure for the dead load.

The relieving arches over the piers have been suggested by the Amidonniers [illegible] they serve for the decoration of the work, and a new [illegible] that the bridge may be something distinctive from the



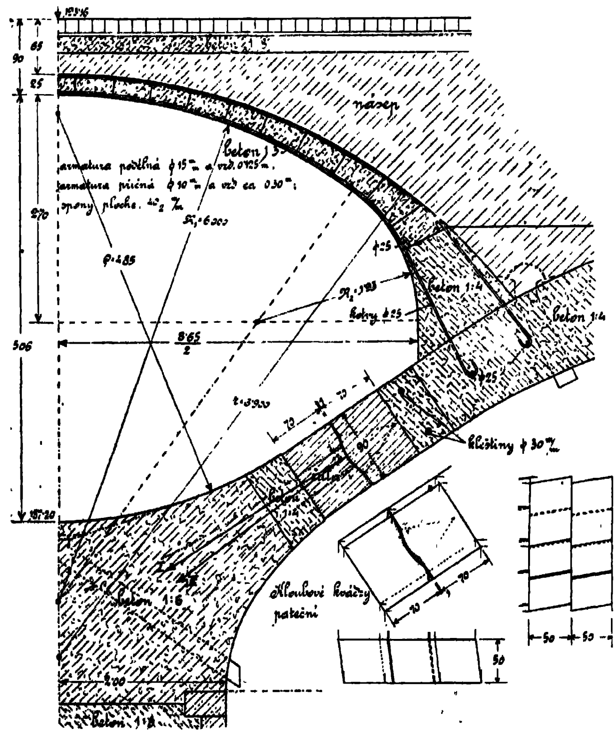
View of portion of completed Bridge.
REINFORCED CONCRETE BRIDGE OVER THE MOLDAU, PRAGUE.

preceding ones and those still to be carried out. (At the present moment a four-arch bridge is being built of 38 and 42 m. span.) They broaden considerably towards the abutments, so that the loads are not concentrated locally.

The available width between the inner faces of the parapets is 16·20 mm., the roadway being 10 m., with two pavements of 3·10 m.

As the arches only have a width of 15·90 m., the parapets are carried in cantilever.

The main spans have been executed in three zones of 6 m. and 7·95 m. width, in contact, but distinct. There was a twofold reason for this. The arches are very oblique, and this simplified the work. It was, as a matter of fact, possible to concrete one zone of each arch in four or five days, and therefore a zone only consists of six large voussoirs. If, on the other hand, the arch had been carried out in one single zone of 15·90 m., it would have been necessary to have a large number of narrow voussoirs.



Detail of Arch over the River.
REINFORCED CONCRETE BRIDGE OVER THE MOLDAU, PRAGUE.

The piers have a width of 4 m. at the abutments and are 1 : 8 concrete, faced with dressed granite back and front, with small ashlars on the sides.

The left and right foundations are respectively 10·70 m. and 9 m. wide, but the concrete is fairly poor — namely, 1 : 12.

The small arches over the Štvanice Island are somewhat irregular. The abutments are on a line sloping at 1 : 215, and the piers are not parallel, as the angle of inclination increases from 69° to 75°. The opening downstream is therefore 45 cm. larger than upstream. It would have been simpler to widen No. 4 pier downstream, but the method adopted makes the bridge lighter, and has gone to prove that the use of concrete permits of this form of construction being employed with ease, whereas it would have been very difficult if carried out in carved stone or metal.

The reinforcement of the lower and upper surface of the small arches consists of rods 20 mm. in diameter and 15 cm. apart. The thickness at the crown is [illegible] cm. The intermediate piers (Nos. 5, 6, and 7) and the abutment, No. 8, have foundations of about 5 m. depth, and are built on wooden piles.

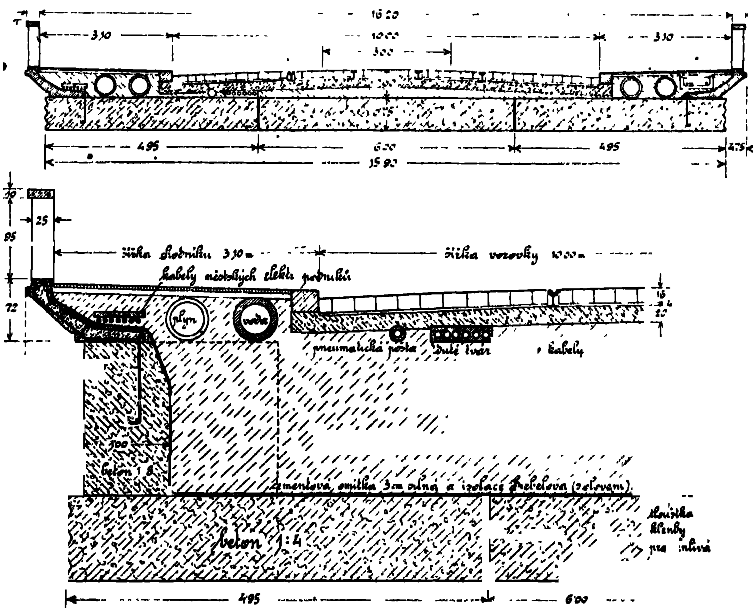
Plain filling has been used over the arches between the facing walls.

The bridge carries a water main of 380 mm., a gas main of 410 mm., and electric cables.

The masts carrying the electric lights and trolley wires of the tramway are also in concrete.

We consider that it is a progressive step that the bridge has not been covered with stone, but that the entire façade should be covered with a layer of finely crushed marble-concrete about 6 cm. in depth. This layer is not smooth, but has a roughened surface to imitate stone. The lower surface of the arches has been squared and finished by means of simple wood moulds.

The foundations for the piers were started in April, 1910, and the work was carried on in such a manner that it was possible in October, 1910, to construct the four arches over the island.



Detail Section through Roadway of Bridge.
REINFORCED CONCRETE BRIDGE OVER THE MOLDAU, PRAGUE.

They were rammed on October 10th, 15th, 21st, and 26th respectively. The centering was removed on December 9th, and the deflection was about 0·4 mm.

The columns for the large arches were completed in May, 1911. The centering presented a certain amount of difficulty—firstly, on account of the navigation, as it had been ordered that an opening of 14 m. should be left. Further, the bed of the river consisted of layers of Silurian rocks, and it was necessary to fix the piles to old rails embedded in the rock. The centerings had sixteen main struts.

The arches were commenced on June 21st, and were successively rammed on July 15th and August 2nd and 22nd.

Each arch was divided into sections, the ramming of which was carried out by commencing with the part nearest the crown, then the abutments, etc. The concreting of each section was completed on the same day. During the work the centering dropped 44, 50, and 58 mm.

According to the design, the surface of the granite blocks in contact with the lead sheets was to be polished, but it has been left fairly rough. As too much deflection was feared, it was decided to compress these hinges before concreting by means of hydraulic presses. The pressure applied was 30 tons (about 30 per cent. of the definite maximum pressure).

The lead hinges are placed 2 cm. out of centre at the crown; they are below the middle line and above it at the abutments.

In each system of links there is friction displacing the resultant from the centre; in this manner it is possible to destroy in part the influence of friction.

Steel links, 30 mm. in diameter, were employed at the grooving joints to act as anchors (twelve links to each arch). Where an arch is on the skew, it is always preferable to place anchors, especially in this case, where the arch is hinged and on the skew, and has no continuous axis of rotation, and thus tends to separate at the zones.

To prevent dampness, two layers of felt asphalt have been placed on the upper surface of the arches, with a thin intermediary layer of lead (0·1 mm. thick).

On September 25th, 1911, the removal of the centering was commenced, with the aid of a Zuffer apparatus. The deflection was from 1 to 4 mm. in the extreme arches and 6 to 10 mm. in the three zones of the centre arch.

The cement used acquired a resistance of 505 to 617 kg. per sq. cm. at the end of twenty-eight days. The 1 : 4 granite concrete attained a resistance of 606 kg. per sq. cm. for cubes of 20 cm. side.

The bridge was tested from February 3rd to 6th, 1912. (During these days the thermometer fell to 16° C.) The central arch of 39 m. and a small arch over the island were tested. Two street rollers of 19 and 16 tons respectively were used in conjunction with eight 13-ton wagons. The rest of the load was made up with bricks (500 kg. per sq. m.). The main arch showed a deflection of 1 mm. with one-half the load, and 1·5 mm. under the total load of 337 tons. The small arch deflected 0·7 mm.

The total construction contains 12,350 cu. m. of masonry :—

Concrete	10,570 cu. m.
Quarrystone (rough)	970 ,,
Dressed Stone (granite)	540 ,,
Quarrystone (dressed)	180 ,,
Brickwork	90 ,,

The carved stonework is only 4 per cent. of the total cubic measurements.

The concrete was mixed as follows :—

Foundations	12	4,050 cu. m.
Piers and Columns	: 8	3,000 ,,
Piers and Columns	: 6	750 ,,
Large Arches	: 4	2,030 ,,
Small Arches	1 : 3	740 ,,

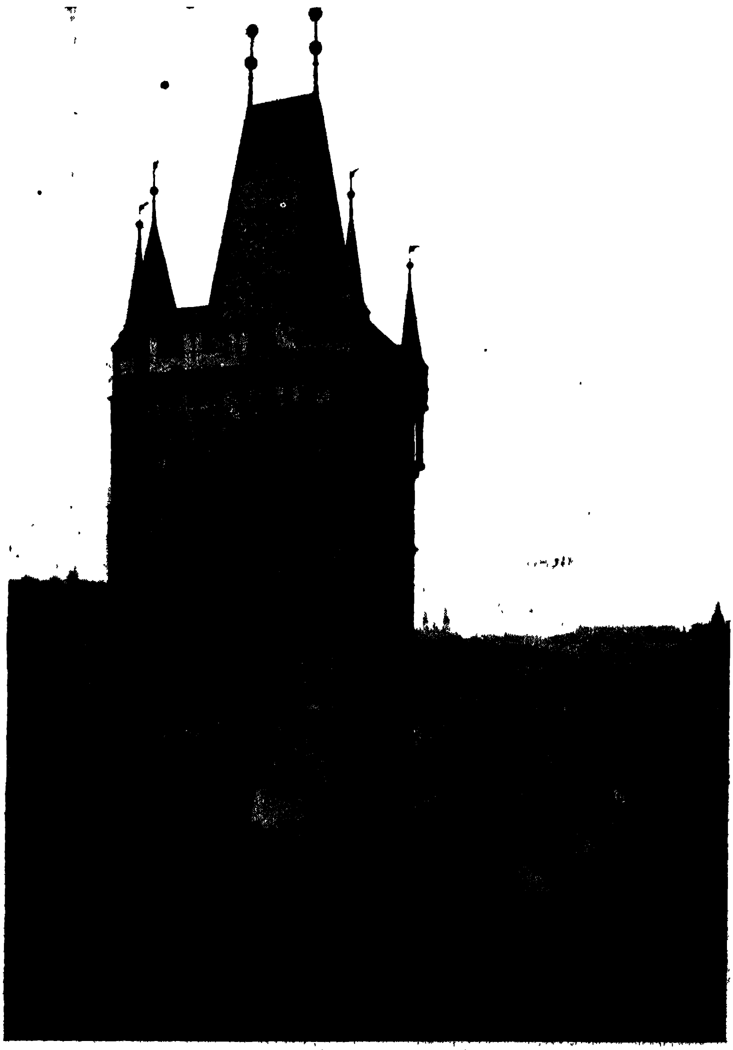
The steel for the reinforcements weighs 90,800 kg. The lead for the joints weighs [illegible] kg.

The net cost of the bridge has worked out at a total charge of francs : [illegible]. This price is comparatively low, as the other bridges in Prague [illegible]

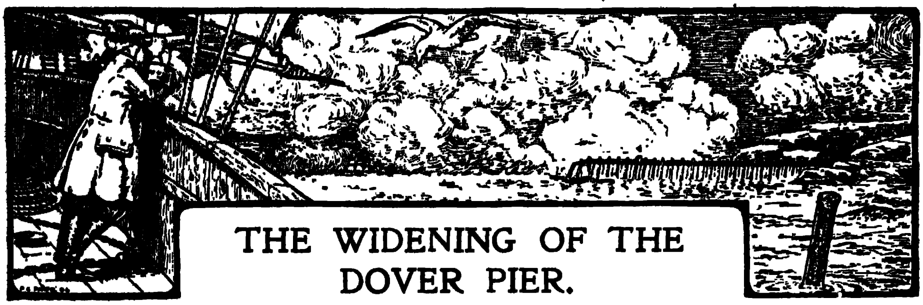
which are of stone or metal have cost from 750 to 850 francs per sq. m., whereas the one here described works out at 350 francs per sq. m.

It should be added that the bridge has a pleasing appearance (especially compared with the steel arch bridges), and the foremost of the young Czech sculptors are at work on its decoration, which is not yet finished.

The bridge was designed by the writer at the offices of the Prague Municipal Commission of Public Ways. The architecture is the work of Mr. P. Janak, and the contractor was Mr. K. Herzan.



VIEW OF THE CHARLES IV. BRIDGE AT PRAGUE.



THE WIDENING OF THE DOVER PIER.

By A. T. WALMISLEY, M.Inst.C.E.
(Engineer to the Dover Harbour Board.)

In view of the important position Dover holds, from a geographical point of view, the following article dealing with the widening of the Dover Pier may claim attention.—ED.

THE stratigraphical position of Dover has probably been more studied in the past than its strategical position. Its geographical position with regard to the Continent gives it premier importance for international communication.

As early as the end of the third century Dover was acknowledged to have been a place of note, but the commencement of the history of Dover as a harbour of refuge is claimed by the fifteenth century. Soon after King Henry VII.'s accession he assisted John Clark, Master of the Maison Dieu, to add to the natural headland a wall of chalk filled in with earth, and to build at its extremity a tower, with the addition of mooring rings, and such was the satisfaction given by John Clark's wall that the haven providing shelter from prevailing south-west winds received the name of "Little Paradise." The wall was strengthened and secured by the natural deposit of shingle from the west, and was intact when King Henry VIII. came to the throne in 1509. Later on an extension of the wall became necessary in consequence of the accumulation of shingle closing the entrance of the harbour—a trouble repeatedly experienced during many generations until the Admiralty Pier was constructed in the latter half of the nineteenth century. King Henry VIII. spent a large sum on work designed to prevent the beach collecting at the harbour mouth and stopping the passage of vessels. With this object he brought by water-carriage blocks of stone and chalk, which were sunk to form a foundation, the intention being to build a mole, or pier, seawards; but prior to its completion other demands on his revenues compelled him to abandon this undertaking. The unfinished work remains to this day, and is locally known as the mole rocks, situated near the present north pier to the inner harbour.

In 1581 the Passing Tolls Act was passed for the benefit of Dover Harbour. By this Act, for every vessel owned or partly owned by subjects of the Crown, of the burden of 20 tons and upwards, laden or discharging within the realm, and passing to or from any foreign country, a toll was levied.

During the seventeenth century the raging question in Dover was undoubtedly the harbour, and King James I. granted a new Charter, which

stated in substance as follows:—The important Port of Dover had gone to decay and was deemed unsafe for ships. It recited that, as Royal patrons, Kings Henry VII., Henry VIII., Edward VI., and Queens Mary and Elizabeth had expended large sums of money upon this port, and that King James I. was also determined to expend money in order to preserve it. A Lord Warden and ten assistants were appointed by the King, with power to fill up vacancies on the board as they occurred, for the government of the whole property of the harbour, with the care of land, houses, buildings, cranes and wharves; and under their Charter, with some additional Parliamentary powers, the harbour was governed till 1861.

In 1610 passing tolls expired by efflux of time, after which Dover Harbour had to depend upon tolls, dues and rents until 1662, when passing tolls were renewed and extended during the reign of Queen Anne (1702-1714).

The date of the seal of the present Dover Harbour Board is 1646.

In 1769 John Smeaton, the eminent engineer, reported upon Dover harbour, but from lack of funds nothing was immediately done.

The "*Public Advertiser*" dated April 13th, 1792 (published at Ivy Lane, Paternoster Row, London), contains a quotation from an evening paper dated March 19th, describing Dover Harbour as being "naturally one of the best in the kingdom," but points out that the entrance is too shallow and that the bar then existing should be removed.

A line of sailing boats between Dover and Ostend was then crossing, weather permitting, twice a week.

In 1844 a Royal Commission reported on the area, outline and materials recommended for an artificial harbour at Dover, together with comments on the position and desirable width of entrance to an enclosed area of 520 acres to form a harbour of refuge; and in 1846 a further report recommended the prescribed area of 520 acres to be considered a minimum requirement for the harbour of refuge at Dover, also that an eastern and western entrance be provided so as to permit a free tidal current through the harbour, with a southern breakwater placed as nearly as possible in the direction of the flood tide, and in a depth of seven fathoms at low water level.

Prior to the commencement of the Admiralty Pier in 1847 the harbour was frequently inaccessible owing to the bar formed near the entrance, when vessels had to lie off in the bay. It is of interest to note that while the concrete blocks used upon the Admiralty Pier as originally constructed were three to seven tons in weight, the blocks in the Admiralty Harbour as now constructed weigh 42 tons as used in the foundations.

In 1861, when the London Chatham and Dover Railway was opened, we find the final abolition of passing tolls, and the control of Dover Harbour is transferred from the Warden and assistants, as constituted by King James I., to a Harbour Board consisting of the Lord Warden of the Cinque Ports, two burgesses of Dover chosen by the Town Council, one representative each of the Admiralty, of the Board of Trade, and of both the South Eastern Railway Company and of the London Chatham and Dover Railway Company. The London Chatham and Dover Railway Company took up the Mail Service.

Captain Morgan was the first Marine Superintendent under the London Chatham and Dover Railway Company. He was thirty-five and a half years in this office, and was succeeded by Captain Dixon, the present Marine Superintendent at Dover and Folkestone.

Among various forms of passenger steamships we find the *Bessemer* steamship, which was an independent venture. The *Castalia* also was extra to the Mail service, but its speed was insufficient. The original *Calais-Douvres'* boiler and funnels soon wore out, and its speed was only 13·2 knots. The *Invicta,* with double rudder, could not conveniently turn in Calais Harbour. Several other vessels of the paddle or ordinary twin-screw type followed.

In 1882 the Dover Harbour Board obtained an Act for works in connection with a deep water harbour, but the works were subsequently postponed pending the Government's consideration of a national harbour.

Referring to the inner basins of Dover Harbour, its existing extrance, 140 ft. between timber framed piers filled with rubble stone to high-water level, leads to a tidal harbour having an area of about 13½ acres, including the area of this entrance passage. Situated in the inner harbour, the Granville Dock has an area of about 4¾ acres within the gates, and the entrance is 65 ft. wide, with 21 ft. clearance over sill at high-water spring tides. The Wellington Dock has an area of 8¼ acres within the gates, and the entrance of 70 ft. wide, with 15 ft. clearance over sill at high-water spring tides.

In 1891, the Dover Harbour Board obtained Parliamentary powers to levy a poll tax of 1s. a head on passengers landing or embarking at Dover, in order to provide funds for an eastern pier, commencing near the Clock Tower, to form the eastern arm of a proposed deep-water harbour, and to provide shelter for a site for a Marine Station on land to be reclaimed from the sea to the east of the Admiralty Pier, also to abandon certain works for which powers had already been obtained. This policy became urgent, as there appeared at the time no certainty that the shelter of a Government harbour would ever be provided upon the south and east of Dover bay, and under this Bill power was obtained for the extension in an easterly direction for a distance of 580 ft. or thereabouts, to form the western head of a commercial harbour, leaving an entrance of 450 ft. between the pier heads.

In 1892 the Dover Harbour Board let a contract to Sir John Jackson for the Prince of Wales Pier works. The shoreward end of this pier, for 1,260 ft., is formed by an iron viaduct, to allow the tide to run through, with a clear headway of 15 ft. above high water, on the supposition that no outside seaworks would then be constructed.

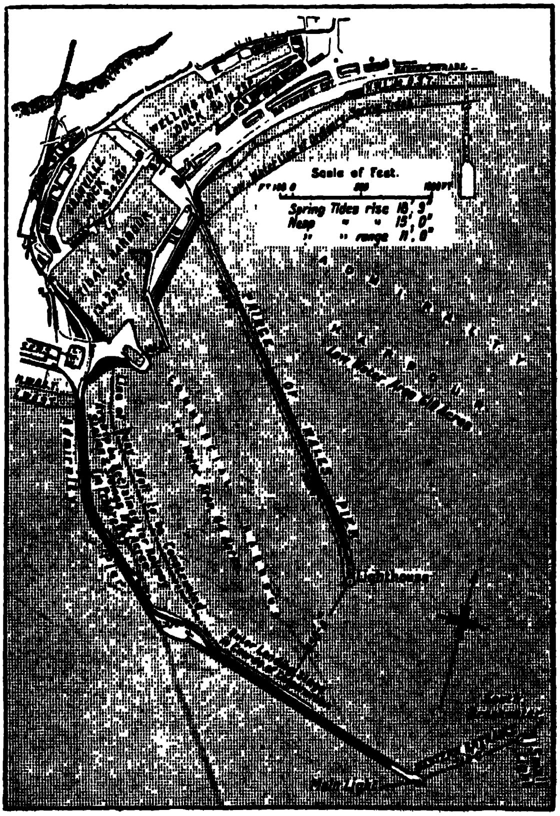
In 1897 the "Naval Works Act" included the building of the Admiralty Harbour enclosing the Harbour Board's eastern pier, and in 1898 the Dover Harbour Board obtained a further Act, extending the area enclosed by the piers upon the east and west sides, and having an entrance of 480 ft., between the then proposed head of the Prince of Wales Pier and the head of a spur suggested to be attached upon the eastern side of the Admiralty Pier extension.

In 1900, the Harbour Board obtained an Act for converting the tidal harbour into a concourse basin, approached by a deep-water lock, and other proposed improvements, and in 1900, at a reception by H.I.M. the German

Emperor at Potsdam, of a deputation of the Harbour Board, the Emperor expressed the opinion that Dover Harbour would become a convenient port of call for the German Atlantic liners.

In 1904 the first passenger train traversed the Prince of Wales Pier and its approach railway on January 27th, and in the same year the landing stage upon the eastern side of the Prince of Wales Pier was subsequently used for the accommodation of Atlantic liners to call at Dover, railway communication being established by the Dover Harbour Board between this landing stage and the S.E. and C. Railway main line at Dover Harbour Station. The s.s. *Deutschland,* Hamburg-American Line, made her first call at the Prince of Wales Pier on July 22nd, 1904.

In 1906 an Act of Parliament was obtained under which the Dover Harbour Board were empowered to render the Admiralty Pier (which was originally constructed only as a breakwater) suitable for the embarkation and disembarkation of railway passengers. By the powers conferred in this Act certain works previously authorised were abandoned, and agreements made between the Harbour Board and the Commissioners for executing the office of the Lord High Admiral of the United Kingdom of Great Britain and Ireland, popularly known as "The Admiralty," also with the South Eastern and Chatham Railway Company, were confirmed.



DOVER HARBOUR. SHOWING RECLAMATION

The turbine system, applied by the Hon. Mr. Parsons after having gained a fame on the River Clyde, was soon extended to the English Channel. The first vessel so constructed was the *Queen,* which was 310 ft. long, and the latest vessel of this type on order is stated to be 345 ft. long. The distinguishing feature of this system is the reduction of vibration to a minimum, while the manœuvring power is manifest to all travellers.

The Prince of Wales Pier forms the boundary between the Admiralty Harbour and the Commercial Harbour, both within the Dock Yard of Dover, and

while the east side of this pier, which is about 2,910 ft. in length, is reserved to the Admiralty, the Dover Harbour Board have provided railway platforms on the west side for use when circumstances render it preferable to bring the mail train by the Prince of Wales Pier railway to this pier, instead of upon the present Admiralty Pier.

In 1909 the reclamation works east of the Admiralty Pier were commenced, designed to provide 11½ acres attached to this pier as a site for a railway station and sidings, and leaving 64 acres at low-water level for the purposes of the outer commercial harbour. This reclamation up to coping level has been executed by the Harbour Board. The marine station will be erected by the railway company on the reclaimed site, and will provide ample accommodation for Continental traffic.

The *modus operandi* for the construction of the reclamation wall is as follows :—In the first instance a staging is built, formed of braced timber piers upon each side of and clear of the foundation site of the main wall. These staging piers are about 40 ft. apart and are built by aid of a cantilever pile driver, being subsequently connected by longitudinal girders, over which Goliath cranes travel. The same triple process has been adopted by Messrs. S. Pearson & Son, the contractors for the present reclamation work, as was followed in the National Harbour construction. The range of spring tide is 18 ft. 9 in. and of neap tide 11 ft. The first operation is the removal of all soft material by large mechanical diggers or grabs, which are lowered either from the Goliath or by a floating crane. The grabs, which are open when lowered, have their projecting teeth drawn together in the sea bed by chain arrangements so as to bring the excavated material above water and deposit it in barges for dispersal at sea. Next follows the service of a large diving bell suspended from the Goliath, which enables the surface for foundation to be accurately levelled, and finally concrete blocks made by machinery are set in position by the helmet diver.

The following description of electric travelling concrete mixer, designed by the late Mr. A. H. Owles, and built by Messrs. Jessop & Appleby Bros., Ltd., Leicester, is of interest in its provision of a very efficient plant, referred to in *Transport* in the following terms :—

" Before proceeding to describe the machines it may be well to direct attention to the reasons which led Mr. Owles to devise this ingenious system. The objects to be attained were the perfect mixture of materials in correct proportions, which is essential, and the immediate delivery of the quite freshly made concrete into the block moulds; also (from an economical point of view), to ensure the work being performed rapidly and economically as regards cost of labour. The importance of these conditions being unerringly fulfilled is evidently necessary when we consider the vast mass of materials required for the making of concrete blocks, and that these blocks are now almost universally employed in the construction of harbours and docks."

The mixing vessel, the capacity of which is one cubic yard, is of the well-known Messent type. It is mounted on a strong steel-framed carriage, provided with two electric motors, one of which revolves the mixing vessel, whilst the other gives a travelling motion to the carriage, so that the operations of

mixing and travelling can be performed simultaneously. The proper charges of materials are fed into the mixer from hoppers and the charging door closed; the machine is then travelled to and over the block mould, the mixing vessel being meanwhile rotated by the motor provided for that purpose. The number of revolutions made are indicated by a dial within view of the attendant, and when about fifteen revolutions are registered—the number required to ensure complete mixture—the mixer motor is stopped (the machine being then in position over the block mould), the mixed concrete discharged, and the machine returned for another charge. Brakes are supplied both to the mixer turning gear and to the traveller motion.

Several other types of machines produce good concrete, but there can be no doubt that the plant now described leaves nothing to chance, every provision being made for the production of perfect concrete at a remarkably small cost for labour.

The motors are of the slow-speed, enclosed, waterproof type required for the rough duty and exposure which is unavoidable in a blockyard. They start easily with considerable overload and are provided with efficient rheostats. The motor for travelling the carriage combines an ingenious and reliable device for maintaining the gear in proper pitch. The travelling wheels are of steel and the axle bearings are fitted with springs. The motor for revolving the mixing vessel is at the opposite end of the carriage, the main driving wheel being enclosed in the wrought-iron casing on the right. The pointer indicates on the dial the number of revolutions made by the mixing vessel, and is in view of the driver.

These machines travel at about six miles per hour, and a strap brake, controlled by the driver's foot, prevents over-running.

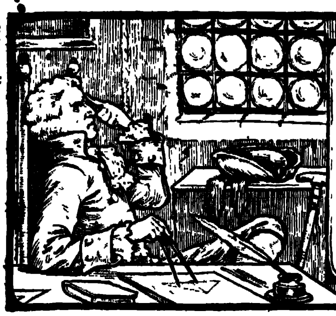
The mixer track is above the block moulds, and the gauge admits of the block being lifted vertically by any suitable crane, usually by a Goliath crane.

The output is about 120 cu. yds. of concrete per day of ten hours, each charge being mixed during the time occupied in travelling from the charging platform to the block mould. Thus, while the output does not much exceed that of a fixed mixing machine, no locomotive or other hauling appliance is required, there is large saving in time and labour, and the concrete is delivered quite fresh from the mixer.

The reclamation wall, 2,260 ft. long, having to stand in an isolated position until the filling at back was executed, was designed by Mr. A. T. Walmisley to be constructed as a 50 per cent. wall—*i.e.*, the width of the base is half the height. The interior between the new wall and the old Admiralty Pier is filled with chalk, which will cover 11½ acres, upon which the new marine railway station is being built, for which concrete piles upon the Considère spiral reinforced system are being prepared and driven. The spiralled concrete piles used at the inset landing are octagonal in section, formed of 3 to 1 Portland cement concrete, reinforced with light vertical iron rods, bound with twisted wire in spiral fashion and shoed with cast-iron points and wrought-iron straps, forming a pile 17 in. by 17 in. across, which was allowed to season for ten weeks prior to driving. The length is 62 ft., and as a rule a set of 3 in. gave satisfaction with a 42-cwt. ram falling 4 ft. 6 in. Some of the railway station

foundation piles are 75 ft. Four berths will be provided along the new wall, consisting of two main berths for embarking and disembarking passengers, one for coaling purposes, and one for emergency. There will also remain the service of a deep-water berth 780 ft. 3 in. long, built of blue gum main piles and provided with two lower landing decks approached by steps. This is at present used for the Continental service in connection with a temporary station accommodation during the progress of the works. Cranes are provided for dealing with baggage, and every endeavour made to expedite transit between water and land; but ports, like men, must be judged not by what they look like, but by what they do. Owing mainly to the geographical position, the traffic between Dover and Calais will always remain predominant. The Channel passenger traffic returns for the week ending Saturday, May 10th, are as follows:—From Calais, 4,970; from Ostend, 1,736; to Calais, 4,069; to Ostend, 3,198; to New York, 14. In regard to the Belgian State Railways, it is officially reported that the number of passengers carried between Dover and Ostend during 1912 was an increase of 12,514 over the previous year. This is said to be due to the fine turbine steamship service of the Belgian State Railway, which has made the sea passage from Dover to Ostend such a short and pleasant one, and has increased the popularity of this route among Continental travellers. When the new railway station and its appendices are completed there is no doubt a large increase of Continental traffic and connections for trans-Atlantic traffic will be the result. The port of Dover possesses an advantage over both the port of Liverpool and the port of Southampton in being an open roadstead, and thus avoiding the time occupied in traversing the approach channel leading to either of these two ports; but Dover is at a disadvantage in having no adequate space for quays, piers, docks, warehouses and sheds, except that reclaimed from the sea, and with the advent of Kent coal this must be provided.

The contract for the New Marine Station is now being executed by The Butterley Iron and Steel Company, of Derbyshire, who built the St. Pancras Station for the Midland Railway. Messrs. S. Pearson and Son, Ltd., who built the Admiralty Harbour, Dover, were the contractors for the pier widening, and Mr. F. W. Duckham, M.Inst.C.E., was their agent. Mr. A. C. Hurtzig, M.Inst.C.E., was consulting engineer; Mr. H. Sadler, M.Inst.C.E., resident engineer, and Mr. A. C. Bonsor assistant resident engineer.



REINFORCED CONCRETE BEAMS.

ON THE RESISTANCE OF BEAMS SUBJECTED TO FLEXURE.

(1) SOLID RECTANGULAR BEAMS—SUPPORTED ENDS FREE (*continued*).

By ALFRED FYSON, M.Inst.C.E.

The first article by the Author on the above subject appeared in our May issue.—ED.

Theory of "Partial Exclusion"—General Conditions and Derivation of the Equations.

Some of the general conditions on which this method is based have already been given, and amongst them it is laid down that the value of the concrete in tension is to be neglected; in some cases it is also specified that there shall be no "tension" cracks in the concrete—a very proper stipulation, but whether it could be actually maintained if the permissible strain on the steel reinforcement were reached is a matter hardly open to doubt.

In order to provide a definite base for these investigations, the particular and limiting conditions of stress and strain will be deduced from the Report of a Joint Committee on Reinforced Concrete to the Royal Institution of British Architects (year 1911).

The only part of that report which is required here is that relating to beams and similar members, the main particulars for which appear to be as contained in Table I. herewith and as follows:—The concrete recommended is a 1 : 2 : 4 mixture; that is, one part of Portland cement, two parts of sand, and four parts of stone aggregates, no stone for the latter being more than ¾ in. in diameter.

The limit of stress on the concrete given in the Table I. is on the supposition that the crushing strength of the material is not less than 1,800 lb. per sq. in. at twenty-eight days old, and not less than 2,400 lb. per sq. in. at ninety days old. In each case the tests for the crushing strength may be carried out on 4-in. cubes, the mixture being permitted to be well punned into the moulds. Generally the allowable working stress on the 1 : 2 : 4 concrete may be taken at one-third of its crushing strength at twenty-eight days old, such stress to be deduced from the average result of the tests taken.

The steel used for the reinforcement ought not to be nearer the surface of the concrete at any point than 1 in. in beams, and ½ in. in floor slabs and other thin structures.

Table I—as compiled from the R.I.B.A. Report.

	Lbs. per sq. in.
Maximum working stress on the concrete in compression (F_c')... ...	600
Maximum working stress on the reinforcement (mild steel) in tension (F_s)	16,000
Modulus of elasticity of the concrete (E_c')	2,000,000
Modulus of elasticity of the steel reinforcement (E_s)	30,000,000

Formulæ constructed on the basis of the above-mentioned particulars are, in the case of beams and similar members, to be framed on the supposition that the "tensional" resistance of the beam is to be taken entirely by the steel reinforcement.

The equations required for the "partial exclusion" theory can be easily deduced from those already determined for the "complete inclusion" theory, as will now be shown :—

Let the diagram, *Fig.* 4, be constructed generally similar to *Fig.* 1, certain symbols being here altered to suit the altered conditions.

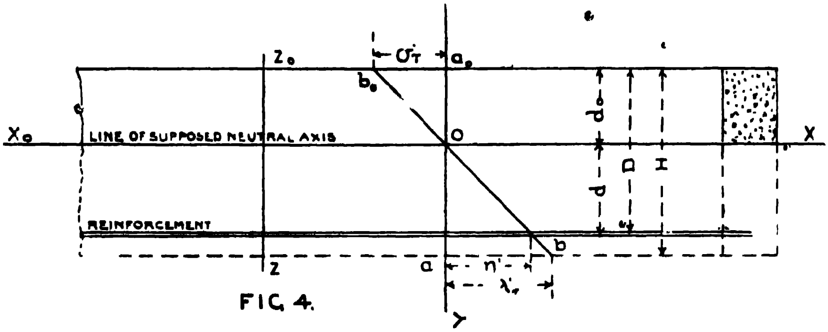


FIG. 4.

(TENSION IN CONCRETE NEGLECTED.

To find d_o, which determines the position of the supposed neutral axis.

From equation (7) the value of the forces in compression is found by making $m=1$, as the stress-strain curve is now supposed to be represented by an inclined straight line.

Calling A_o' the sum of the forces in compression and substituting d_o for v_o,

Then $$A_o' = \frac{BF_o'd_o}{2} \qquad (17)$$

For internal static equilibrium the forces in compression and tension must balance. As the tension in the concrete is to be neglected, the reinforcement alone has to provide the necessary resistance. Let A_s' denote the value of the forces in tension, due to the extension of the steel reinforcement.

Then $$A_s' = A_o' = \frac{BF_o'd_o}{2} \qquad \text{(xxvi)}$$

From (9) by changing A_s into A_s' and v_o into d_o it is found that

$$A_s' = a_s E_s \sigma_T \left(\frac{D}{d_o} - 1\right) \qquad \text{(xxvii)}$$

Also $$A_s' = a_s F_s \text{ whence } a_s = \frac{A_s'}{F_s} \qquad \text{(xxviii)}$$

The first part of (xxviii) is due to the fact that the total resistance of the reinforcement is the product of its sectional area a_s and the permissible unit stress F_s.

Substituting in (xxvii) the value of a_s in (xxviii), and for σ_T its value given in (10) also changing E_c into E_c', there results the following equation which must be solved for d_o.

$$1 = \frac{E_s F_o'}{E_c' F_s}\left(\frac{D}{d_o} - 1\right) \qquad \text{(xxix)}$$

Whence $$d_o = \frac{D}{1 + \frac{E_c' F_s}{E_s F_o'}} \qquad (18)$$

For the symbols in (18) let their numerical equivalents in Table I. be substituted.

Then $$d_o = \frac{9D}{25} \qquad \text{(18A)}$$

Equation (18A), which is a special form of (18), is so expressed as to be in accordance with the given numerical values contained in the R.I.B.A. Report.

To find M'_R, the moment of resistance at the section aa_0, Fig. 4.

This is the sum of moments of the internal forces in compression and tension about the supposed neutral axis X_0OX, as determined by d_0.

Thus $$M'_R = M'_0 + M'_s \qquad (19)$$

In which M'_0 is the moment of resistance due to the compression in the concrete, and M'_s is that due to the resistance of the reinforcement in tension.

In (13) change M_0 into M'_0, v_0^2 into d_0^2 and make $m = 1$.

Then $$M'_0 = \frac{BF'_0 d_0^2}{3} \qquad (20)$$

For the moment of resistance M'_s of the steel reinforcement; in (xxiv) change M_s into M'_s, A_s into A'_s and v into d.

Then $$M'_s = A'_s d \qquad (xxx)$$

The value of A'_s is given in (xxvi), and as d is equal to $D - d_0$,

Then $$M'_s = \frac{BF'_0 d_0}{2}\left(D - d_0\right) \qquad (21)$$

Collecting the terms on the right-hand sides of equations (20) and (21) and reducing,

Then $$M'_R = \frac{BF'_0 d_0^2}{6}\left(\frac{3D}{d_0} - 1\right) \qquad (22)$$

For the symbols in (22), let their numerical equivalents in Table I. and equation (18A) be substituted,

Then $$M'_R = 95{\cdot}04BD^2 \qquad (22\text{A})$$

Equation (22A), which is a special form of (22), is so expressed as to be in accordance with the given numerical values contained in the R.I.B.A. Report.

As the foregoing equations (17) to (22A) are derived from quasi-scientific particulars —one important element of the beam being entirely omitted—they can only be regarded as purely empirical, and at the best are only approximations more or less applicable to some special case. They are, however, accepted in a general sense in principle by many writers on the subject, and most of the work of actual construction is designed according to their results; and, although those results are not always in harmony with expectations, due respect must nevertheless be paid to methods—in whatsoever manner they may be derived—which are apparently generally recognised as suitable for ordinary practical requirements.

It is sometimes required to increase the strength of a beam without increasing its exterior dimensions, and this is effected by augmenting the sectional area of the reinforcement beyond that given by equation (xxviii); it is not intended to consider here any details relating to such increase of strength, but it may be mentioned that in general the actual increase will be found to be small compared with the considerable and sometimes large augmentation of metal required to effect it.

Primal Numerical Data for comparing the two Theories.

For the direct comparison which is to be instituted between the two methods just examined and formulated algebraically, it is necessary to determine various numerical data which will be required to serve as primal or initial quantities for such comparison. The computation of such data is effected by means of the equations (17) to (22A), and in accordance with the conditions of the "partial exclusion" theory, the provisions set forth in Table I. and those accompanying it. Let a beam of reinforced concrete be assumed, its section being of some definite dimensions, and let such section be maintained throughout for purposes of the comparison.

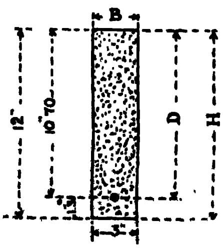


FIG. 5

***Fig.* 5 represents a section of the proposed beam, the dimensions being as there stated, and the reinforcement consisting of a steel rod or bar.**

The results contained in the following Table II. have been calculated in accordance with the particulars given above, and they form the primal numerical data required for the comparison.

TABLE II.

"Partial Exclusion" Theory—Tension in Concrete Neglected. Vide Fig. 4.

Primal numerical data for comparative results:—

M_R'—The Moment of Resistance of the section	32,643 in. lbs.
d_o—The distance below the top of the beam to the plane of the Neutral Axis	3·852 in.
a_s—The sectional area of the steel reinforcement ...	0·2167 sq. in.
σ_T'—The shortening of the concrete in compression on a length of one inch due to F_o', *i.e.*, 600 lbs. per sq. in.	300 millionths of an inch.
η'—The lengthening of the steel reinforcement in tension due to F_s, *i.e.*, 16,000 lbs. per sq. in. ...	533 millionths of an inch.

Although the concrete in tension is neglected so far as calculation is concerned, it is supposed to remain unimpaired throughout; it will, therefore, be subjected to the ordinary conditions of bodies under the influence of Flexure, consequently, there will be an extension λ_T' at its lowest plane, which is deduced from the following ratio:—

$$\lambda_T' : H - d_o :: \sigma_T' : d_o \qquad (23)$$

in the present instance then $\lambda_T' = 637$ millionths of an inch.

The meaning of this last equation (23) and its result is that in order to permit the steel to take its full permissible stress of 16,000 lbs. per sq. in., and therefore its full extension η', the concrete at the bottom of the beam would have to elongate 637 millionths of an inch on one inch, an amount equivalent to $\frac{1}{1570}$ of its length: failing that, it would be ruptured up to some point in the depth of the beam where the extension due to Flexure would not be beyond the limits of that possessed by the concrete.

"Complete Inclusion" Theory.—Plain Concrete subjected to Compression or to Tension.

The Elastic Stress-Strain Curves. — Before working out numerical results according to a rigorous theory it is necessary to deduce from experimental tests on the concrete of a 1 : 2 : 4 mixture, as specified in the R.I.B.A. Report, the general behaviour of and the relation between stress and strain in such a material, not only for compression but also for tension. A rational and adequate knowledge as to those attributes presents formidable difficulties both for compression and tension; as regards compression, not so much on account of lack of experimental tests—for they are numerous and often carried out with great precision and refinement—but by reason of the fact that those tests are not pursued far enough to determine what are the limits of strain, when the material is in a state of perfect elasticity; as regards tension, altogether on account of the paucity of tests which have been publicly recorded, and the unsatisfactory and inadequate results of those tests from a scientific as well as from a practical point of view. The difficulties which attend the process of testing concrete in direct tension are no doubt very considerable, and it appears it cannot be extended for efficient observations beyond certain comparatively low stresses; but the bulk of literature on the subject appears to dismiss it in something like the following manner:—"It is of but little importance and will not be required in the calculations; there is then no particular necessity to trouble about it." It will be seen in the sequel whether such a system of neglect should be continued.

Experimental tests appear to establish the fact that so far as the "set strain" is concerned it has no direct influence on the ultimate strength of any material of ordinary construction, and that internal resistance is due entirely to "elastic" properties. The

results of tests also go to prove that the "elastic strain"—which vanishes with discontinuance of stress—is for any particular specimen the same linear measure for the same intensity of stress, no matter how often that stress is repeated. There is a culminating point at which the specimen breaks down, the exact cause of failure not being really known—possibly it may be attributable to shear—but elastic strain in the same body appears to remain a practically constant quantity for a constant intensity of stress.

If, then, the elastic strain has physical qualities of that nature it must be governed by regular and definite laws; in such case the general form and characteristics—but not necessarily the distinctive physical properties—of the stress-strain curve would be similar for all materials, differing only in accordance with the kind of stress imposed. Thus in the case of the elastic stress-strain curve for tension, it is always found convex to the axis of stresses; in the case of compression, however, no such decided character can be deduced from the results of recorded tests, for the curve is found sometimes convex, sometimes straight, and occasionally concave to the axis of stresses; and the last-named direction may perhaps be the correct one.

The Compression Stress-Strain Curve.—The particulars for forming this curve were taken from the Watertown Arsenal Reports, U.S.A., and so far as they go they appear to be well-nigh perfect, not only on account of the magnitude of the specimens tested, and their number and catholicity, but also on account of the comprehensible explanations accompanying the results of tests, and the refinement to which those tests were carried. Unfortunately for the purposes of the present investigations, a material exactly comparable with the mixture of concrete as specified in the R.I.B.A. Report does not appear to be included, and in the instances where a 1 : 2 : 4 mixture is operated on, the amounts of "set" were not taken after the first application of the applied loads on the specimens; therefore a true conception of the "elastic" stress-strain curve cannot be formed with precision. Enough, however, is contained in those valuable tests to show in what manner that curve tends to shape itself. The results which have been made use of are contained in the Reports for the year 1904, and those required here are set forth in Table III. The specimen tested was a column 94·73 inches in length, the section being nearly square—12·66 in. × 12·59 in.—therefore it does not come into the category of "long" columns. The concrete consisted of a mixture 1 part "Vulcanite" Portland cement, 2 parts clean sharp sand, and 4 parts pebbles from ½ in. to 1½ in. in diameter. It was set in air and tested at 3 months and 17 days old. Measurements were taken on a gauged length of 50 in. in the middle part of the column.

TABLE III.

1 : 2 : 4 Pebbly Concrete under Compression.

Applied Load per square inch.	Gauged Length—50 inches.		Remarks.
	Total Shortenings.	Set.	
lbs.	inch.	inch.	
100	0.	0.	Initial Load.
150	.0006	—	
200	.0013	0.	
250	.0022	—	
300	.0030	.0003	
350	.0039	—	
400	.0050	.0007	
450	.0060	—	
500	.0070	—	
550	.0080	—	
600	.0090	.0017	
1,710	—	—	Ultimate strength.

This description of the materials constituting the test piece agrees fairly well with the R.I.B.A. provisional requirements except as regards the scantling for the aggregate, as pebbles up to 1½ in. instead of ¾ in. in diameter were used. The variation as regards the elasticity of two such mixtures up to a stress of 600 lbs. per sq. in. would hardly be of much importance when the age of the specimen is taken into account; a slight modification has, however, been herein introduced in order to lessen the effect of that variation.

The experiments on the column were continued in a similar manner to those given by the results shown in Table III. up to its ultimate strength, and therefore the same load was never applied more than once. Apparently the initial load of 100 lbs. per square inch remained always applied.

In the diagram *Fig.* 6 is delineated the compression stress-strain curve Oc_oc_o as deduced from the results given in Table III, the axis X_oOX being the axis of stresses, and YOY_o being that of strains; these latter are taken to represent the "elastic" strains—that is "set" deducted—and they are plotted as for millionths of an inch on a length of one inch.

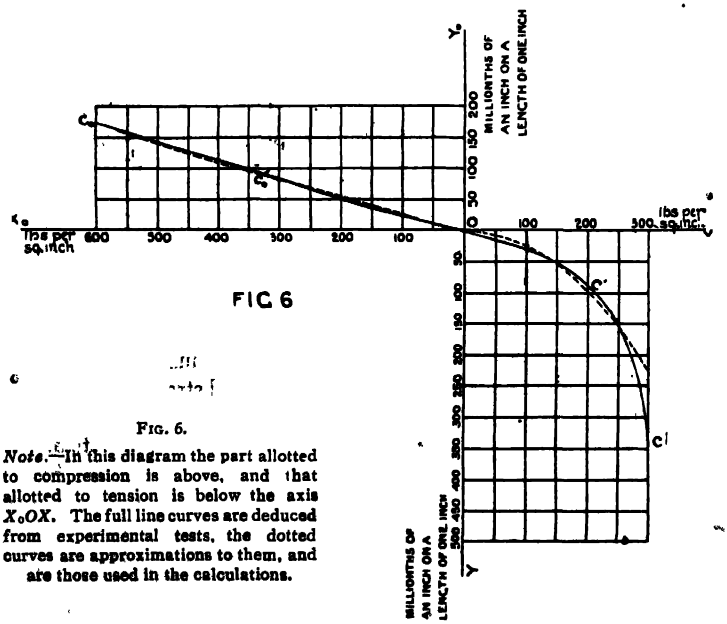


FIG. 6.

Note.—In this diagram the part allotted to compression is above, and that allotted to tension is below the axis X_oOX. The full line curves are deduced from experimental tests, the dotted curves are approximations to them, and are those used in the calculations.

It will be noticed that although this curve approximates to a straight line, yet in reality it consists of two curves meeting in such manner that at a stress of about 350 lbs. per square inch there is a point of contrary flexure; from that point as the stresses increase the curvature is concave, and as they decrease it is convex, to the axis of stresses. In such case the curve Oc_oc_o can hardly be considered a true elastic stress-strain curve, for there is no other force being applied which would cause a reversal of curvature; therefore the only conclusion which can be arrived at is that the whole of the "set" is not comprised in the results as shown in Table III. But the curve is herein accepted as shown, for it is fairly typical of many examples contained in the Watertown Reports.

An exponential equation which will approximately define the stress-strain curve $Oc_0'c_0$ is

$$\sigma = Cf^{\frac{1}{m}} \tag{24}$$

in which the exponent m and the coefficient C are found to be as follows—

$$m = 0{\cdot}95 \tag{25}$$

$$C = \frac{1}{4{,}900{,}000} \tag{26}$$

A special form of the equation (24) in which F_0 is some particular stress and σ_T its corresponding strain is—

$$\sigma_T = CF_0^{\frac{1}{m}} \tag{24A}$$

The dotted curve *Fig.* 6 running almost coincident with the stress-strain curve $Oc_0'c_0$ represents that curve according to the calculated results of equation (24), and it will be noticed that the approximate can hardly be distinguished from the real curve.

On the actual course of the "Compression" Stress-Strain Curve.

A remark has been previously made that the correct form of the "perfectly elastic" stress-strain curve for compression may perhaps be such that it is concave to the axis of stresses. This may be a somewhat bold suggestion to make, as it certainly is a heterodox opinion to hold, but in support thereof it may not be out of place here to examine the contention briefly—to examine it at proper length would be to enter into a lengthy and complex disquisition.

In the diagram *Fig.* 6A, let OX_0 be the axis of stresses and OY_0 that of strains. The curve $Oa_0'a_0$ is plotted from the results in Table III. headed "Total Shortenings," and the curve $Oc_0'c_0$ is plotted from the same results after deducting the amounts recorded for "set"; thus the former curve shows the total strains including the set, and the latter curve the "elastic" strains according to the tests as carried out. The two curves $Oc_0'c_0$ *Figs.* 6 and 6A, are, it will be noticed, identical.

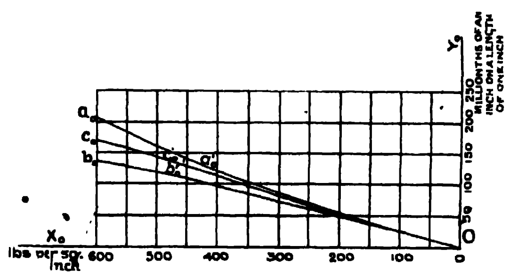


FIG. 6A

Now there is good reason to suppose that the whole of the set was not eliminated by the first application of the test loads, and there is also reason to suppose that had those loads been applied a second time the set would have been further increased, and so on until no set remained, when the curve would eventually assume some such form as is shown by the line $Ob_0'b_0$ which is delineated as a curve concave to the axis of stresses. Thus the first stress-strain curve $Oa_0'a_0$ defines the co-efficient of elasticity to be continually decreasing in value as the stresses increase—and this is the general assumption when it is not supposed constant—whereas the last, and assumed perfectly elastic, stress-strain curve $Ob_0'b_0$ defines the co-efficient of elasticity to be continually increasing in value as the stresses increase.

A theory might be advanced in support of this view of treating the compression stress-strain curve—not only for concrete but for all elastic substances—but in the present instance it will be simpler to rely on the results of practical experimental tests for such support. Thus, indiarubber shows the characteristics of the concave curve as just propounded in a marked degree, cast-iron also gives similar results, the curvature in that

case being not so strongly defined, as may be easily understood. Tests on neat Portland cement could be given which clearly prove the stress-strain curve for compression to be concave to the axis of stress, and experiments on sandstone are found to give a similar result. If then the co-efficient of elasticity for neat cement and for sandstone, taken as separate materials, continually increases in value as the stresses increase, it is reasonable to assume that when they are combined in the form of concrete they will not produce a contrary result.

The general effect, as regards stresses and strains due to flexure, produced by an increasing value of the co-efficient of elasticity would be to cause some augmentation in all the stresses beyond those due to a compression stress-strain curve convex to the axis of stresses, but any such augmentation would of course depend entirely on the degree of curvature; the numerical value of the exponent m being changed into some quantity greater than unity instead of ·95 according to equation (25). The subject will, however, not be further considered here, as the theory of a concave compression stress-strain curve will not be embodied in any of the formulæ contained in these investigations, and mathematical proof of such theory must be left to be dealt with elsewhere.

The Tension Stress-Strain Curve.

After diligent research it has not been possible to discover any comprehensive or reliable results defining the relation between stress and strain in tension, whether as derived from direct axial tests on a specimen or from measured tests on beams under flexure, except in some isolated instances which do not extend beyond low stresses. Consequently a stress-strain curve for tension could not be produced in so definite a manner as that delineated for compression. Recourse was, therefore, had to a species of induction for the construction of the required curve, and the tension stress-strain curve Oc_tc_t—*Fig.* 6—was consequently evolved in the following manner:—The co-efficient of elasticity for the compression stress-strain curve Oc_oc_o when the stress is zero is nearly 4,000,000 lbs. per sq. in., and this defines the tangent to the curve at O its origin; it also defines the tangent of the tension stress-strain curve at this same point, for the generally accepted theory is—and the results of experimental tests tend to confirm it—that where the two curves meet, they have a common tangent; therefore, the direction of the required tension curve at its commencement becomes known, and values below which its ordinates cannot lie are provided. Two definite extensions as ordinates to the curve were then plotted, one being 31 millionths of an inch for a stress of 100 lbs. per sq. in., and the other 85 millionths of an inch for a stress of 200 lbs. per sq. in. These two important ordinates—for they practically fix the form of the tension stress-strain curve—were deduced from experiments carried out by Professor W. H. Henby, and are contained in his paper on the "Elastic Properties and Ultimate Strength of Concrete," published in "The Journal of Association of Engineering Societies" for the year 1900.

The concrete tested was a 1 : 2 : 4 admixture, the stone aggregate being limestone macadam up to 1¼ in. in diameter. It was well tamped in the moulds, covered with damp cloths for the first two days and experimented on and tested to destruction at 30 days old. The testing was by direct axial tension and several diagrams of stress-strain curves for the various specimens are given; in one of them, of a fairly regular character, the extension at 100 lbs. per sq. in. appears to be about 28 millionths, and at 200 lbs. per sq. in. about 77 millionths of the length of specimen tested. The material was probably somewhat "stiffer" than that composed of smaller stone only extending up to ¾ in. in diameter, and the rate and total amount of its extensibility compared with the stress imposed were less than is found in concrete consisting of sand and small stones, preserving the same proportions for the various ingredients. On

the other hand the extensions given for the limestone mixture are total extensions which include those due to "set," and the required values are the "elastic" strains, or those from which the set has been eliminated either practically or by computation; consequently some qualification became necessary in order to reduce the "total" to "elastic" extensions only.

There is probably some direct relationship between the stress-strain curve of a material under compression and that of the same specimen under tension: assuming such to be the case it was thought that certain tests on two sets of 1 : 2 : 4 concrete columns carried out at the Watertown Arsenal might perhaps supply some fair means of approximation for the required qualification. The aggregates for the respective columns consisted of trap rock up to 1½ in. and ½ in. diameter; the total strain at high stresses showed an increase of some 15 per cent. for the mixture containing the smaller over that containing the larger stones.

Taking that percentage as a basis and making certain allowances, it was considered that an amount of 10 per cent. added to the two extensions of 28 and 77 millionths of an inch previously given for the limestone concrete in tension would furnish the desired qualification. Such additions give the 31 and 85 millionths forming the two definite ordinates for the tension stress-strain curve *Oc'c*, *Fig*. 6, at their respective abscissæ of 100 lbs. and 200 lbs. per sq. in. Thus the direction at its origin, and two points on the required curve were found, but it was necessary to determine yet another point, so that the extension at some assumed or probable ultimate stress might be established. An equation in the form $y=ax+bx^2+cx^3+$, etc., carried to the 5th degree, was formulated, and was made to satisfy so much of the curve as was already known. Calculations were then made as for a stress of 300 lbs. per sq. in.—that intensity being supposed to be outside the limits of the probable actual ultimate strength—and the corresponding extension was found to work out to 340 millionths of an inch on a length of one inch. The curve *Oc'c* is plotted from the values derived in the manner just described, and it is intended to represent the "elastic" stress-strain curve for the concrete specified in the R.I.B.A. Report.

It will be noticed that beyond a stress of about 200 lbs. per sq. in. the extensions increase at a very much faster rate than the stresses; this character of the material in general accords with the tendency shown by experimental tests and with eminent opinion on the subject.

In a reinforced concrete beam M. Considère maintains that after some unknown but high intensity of stress in the concrete is developed, such stress remains constant, whilst extensions continue to increase with the increase of extensions due to the steel reinforcement up to a point where the metal ceases to be uniform in its manner of extending, and then the concrete becomes ruptured.

Such a theory does not commend itself as being essentially rational, nor is it generally accepted; but it cannot be disputed that Considère's experiments show conclusively that after some more or less ill-defined degree of stress is reached, the rate of increase in the extensions is very rapid; and this is so well borne out by the form of the curve *Oc'c*, *Fig*. 6, as almost to harmonise with his theory.

Concrete, however, is a material which probably does not differ in its elastic properties—except in degree—from other natural substances, and as in them increased extensions are found to be due to increased stress, so in concrete an increase in the extension can only be the result of an increase in the stress: the increments of stress may, and apparently do, eventually become smaller and smaller, as the corresponding increments of strain become greater and greater.

An exponential equation which will approximately define the stress-strain curve $Oc'c$, *Fig.* 6, is:—

$$\lambda = Kf^{\frac{1}{n}} \qquad (27)$$

The exponent n and the co-efficient K are found to be as follows:—

$$n = 0{\cdot}50 \qquad (28)$$

$$K = \frac{25}{10^{10}} \qquad (29)$$

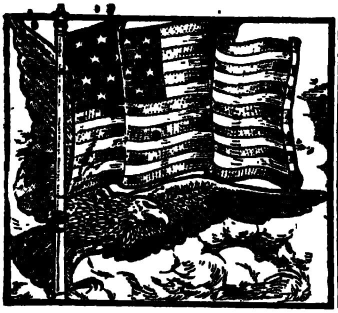
A special form of the equation (27) in which F is some particular stress and λ_T its corresponding strain is:—

$$\lambda_T = KF^{\frac{1}{n}} \qquad (27A)$$

The dotted curve, *Fig.* 6, running alongside and through the stress-strain curve $Oc'c$ represents that curve according to the calculated results of equation (27).

It will be observed that those two curves do not differ from each other to any great extent between f=say 75 lbs. and f=say 275 lbs. per sq. in. Below 75 lbs. per sq. in. the dotted curve is known to be erroneous, but the effect on the calculations will be quite insignificant; above 275 lbs. per sq. in. the dotted curve begins to increase in error perceptibly, but as subsequent calculations show that the probable maximum stress involved will not exceed 260 lbs. per sq. in., such error may be regarded herein as harmless.

(*To be continued.*)



CONCRETE PAVEMENTS—METHODS AND COST OF CONSTRUCTION.

By CARL M. BOYNTON

The following is taken from a Paper read before the American Society of Engineering Contractors. We would also refer our readers to an article on Concrete Roads which appeared in our March and May numbers.—ED.

THE development of concrete as a paving material is unique. Where most permanent pavements have ultimately been declared a success only after years of expensive experience and many failures, concrete has given satisfaction practically from the start. This is no doubt due, in great part, to the knowledge in handling concrete which contractors have gained in other lines of construction, and thus have been able to avoid conditions which might result in failure. However, the success of concrete is largely due to its possessing every essential of an ideal pavement.

The principal features of the ideal pavement have been very ably summarised by Mr. Linn White, engineer, South Park Commissioner of Chicago, as follows: "A pavement should be inexpensive and flexible in cost, simple of construction, without endangering its permanency. It must be dustless, noiseless, resilient, smooth, non-slippery, clean and of agreeable colour to the eye." That concrete pavements practically fulfil all of these requirements has been fully demonstrated wherever they have been intelligently laid.

In discussing the subject of concrete pavements, it is proposed to adhere strictly to the subject of plain and reinforced concrete, without discussing any of the many patented materials used for the surfacing of the concrete.

The two methods of concrete pavement construction which have been used to such an extent throughout the country as to be accepted practically as standards, are single-course and two-course work. The relative cost of materials that can be obtained will be the determining factor as to the type of pavement to use. If hard, durable crushed rock or a clean, hard gravel cannot be obtained at reasonable cost, then one-course work should not be undertaken.

The wear to which a concrete pavement is subjected is due to abrasion and impact; therefore, in planning and building a concrete pavement every effort should be directed toward obtaining the highest degree of resistance to such action. It is apparent that to obtain high abrasive resistance in a pavement, an aggregate having high resistance must be used. The same will apply to impact. Therefore, it is essential that concrete for a pavement must be composed of a hard, tough aggregate. But it is just as essential that the concrete itself be uniformly hard and tough, and with the proper materials this can be obtained only by the employment of methods which insure proper proportions —thorough mixing, correct consistency, and uniform distribution and compacting of the concrete over the area being paved. These may be considered excessive precautions, but results indicate the advisability of using precise methods.

FOUNDATION.

A foundation for concrete pavement is essential and should be of such a nature and so prepared that sub-drainage is assured. All soft and spongy material in the sub-base

should be removed, and replaced with bank-run gravel, sand, or other material equally as good, and the whole foundation thoroughly compacted with a power roller.

A flat sub-base is more easily obtained than one that is crowned, and, on narrow streets up to 20 ft. in width, a better distribution of the concrete results by placing the crown entirely in the pavement proper. A careful checking of the elevations of the foundation is important in order to insure the proper thickness in the finished concrete.

Fig. 1. Pumping Equipment for use on concrete road.
CONCRETE PAVEMENTS.

Fig. 2. General View of the operations of a concrete road construction gang.
CONCRETE PAVEMENTS.

No pavement should be less than 5 in. thick at the outer edge or curb, nor for economical work should it be greater than 8 in. at the crown. In pavements of greater width than 20 ft., the desired crown may be obtained by forming both foundation and concrete.

ONE-COURSE WORK.

The one object to be desired in all construction work, and particularly in the use of concrete, is simplicity. One-course work, that is, the construction of a pavement where the mixture is similar throughout and the work is done in one continuous operation, is therefore desirable. The points to be considered in a study of this type of pavement are: Materials, Proportions, Methods of Mixing and Placing, Thickness of Pavement, Expansion Joints, Finishing and Curing.

Materials—Aggregate.—The coarse aggregate of one-course work should be well graded gravel or crushed rock, ranging in size from ¼ in. to 1½ in. in largest dimension.

The fine aggregate should be clean, coarse sand, well graded from fine to coarse, all of which should pass through a No. 4 sieve, and not over 5 per cent. pass through a 100-mesh standard sieve.

The cement should be standard Portland cement, complying with standard specifications.

Proportions.—The leanest concrete which should ever be used in a one-course pavement is a 1 : 2 : 4 mixture. Such proportions will usually give a satisfactory finish and are suitable for streets and roads of moderate traffic. For all other traffic conditions richer mixtures should be used. In some cases concrete composed of one part cement, one and one-half parts sand, and three parts coarse aggregate has been employed with splendid success, and with similar material and under like conditions 1 : 2 : 3 mixtures seem to give equally as good results.

Mixing and Placing.—As the pavement is dependent for its success upon uniformity, the mixing should be done mechanically in a type of mixer which insures the uniform proportioning of all materials throughout the mass. The concrete should be of a consistency requiring but little tamping to flush the surface with water.

The usual method followed in placing concrete is that of placing the concrete directly on the street from the mixer, and not handling it the second time by wheelbarrows. This is sometimes accomplished by the use of a boom and bucket attached to the mixer, the bucket usually being of the bottom-dump or tilting type, the boom swinging in an arc of 180 degrees. Another method is by the use of a spout or flume from the mouth of the mixer, discharging the concrete directly upon the road, this spout being so attached that it may be swung easily in an arc of 180° and the mix discharged while the spout is in motion.

Thickness.—The thickness of the pavement is a very important question and one which experience alone can answer. Developments to date seem to indicate that at the crown of the road nothing less than 7 in. should be used. In country highways the minimum thickness of the edge should be 6 in., while in some city pavements where the edges are protected by curbs a minimum of 5 in. is allowable.

Expansion Joints.—It is admitted that expansion and contraction must be taken care of in concrete pavements, but the amount of movement which should be provided for and the distances at which joints should be placed, are points not definitely settled. Joints lengthwise through the pavement are objectionable, therefore, in most cases the concrete is placed in a continuous sheet or slab from edge to edge with joints across the pavement, varying from 15 to 30 ft., according to the idea of the engineer writing the specifications. Pavements laid with three-eighths joints every 25 ft. have proven very satisfactory and this arrangement of joints is being accepted as good practice.

Since the edges of the joints are apt to be chipped, it has been found advisable to protect them with plates or angles. These plates are clamped together face to face with a strip of ½-in. tarred felt between, and are set up and concreted into position. The effective joint, so far as the expansion is concerned, is reduced to whatever the felt can be compressed.

In case of street work where curbing is used, longitudinal joints should be provided

between the pavement and the curb. These do not require the protection of metal plates; for such longitudinal joints a plastic filler is preferable to a tarred-felt filler. All joints not protected by metal should be rounded to a radius of ½ in.

Finishing.—It is generally accepted that the best method of finishing a concrete pavement is to wood-float the surface after it is struck off with a template. Sometimes

Fig. 3. Showing the discharging of the concrete upon the sub-base.
CONCRETE PAVEMENTS.

Fig. 4. Steel Protection Plate for Expansion Joints.
CONCRETE PAVEMENTS.

the floated surface is brushed with a stiff fibre broom; but this is not necessary and is not recommended.

It is considered advisable to corrugate all grades of 5 per cent. or more.

Curing.—It is impossible to put too much emphasis on the importance of thorough and proper curing of pavements. After the concrete is placed it should be covered with earth, or other absorbent water-retaining materials, which should be kept damp for a

period of not less than five days, so that the moisture in the concrete, necessary to its proper hardening, will not be lost. The pavement should be protected for at least another period of five days before traffic is allowed upon it.

TWO-COURSE WORK.

In some localities, due to available materials, two-course work is better and cheaper than single course. Such a condition exists where the coarse aggregate is not tough enough to resist traffic, and granite screenings, or a clean sharp sand, can be obtained for the top course. Two-course work requires more careful handling and more experienced labour in its construction than one-course. The difficulty in bonding fresh concrete to partially hardened concrete is well known, and it is this feature that must be watched carefully in two-course work.

The bottom course should consist of at least $5\frac{1}{2}$ in. of well-made concrete. The aggregate should conform in general to that described for one-course work, but may consist of material of lower abrasive value.

The top course, $1\frac{1}{2}$ in. in thickness, should be composed of a $1:1\frac{1}{2}$ part cement and fine aggregate in which the aggregate is either granite chips graded from fine to $\frac{1}{2}$ in. in size, or coarse sand well graded from fine to coarse, the largest particle of which will pass a $\frac{1}{4}$in. screen.

Mixing and Placing.—The main difficulty encountered with two-course work is in placing the wearing course upon the base in such a manner as to ensure a perfect bond. A simple method of ensuring successful work is in the use of two mixers—the secondary mixer being used for the top course. In this way the placing of the top is carried along simultaneously with the placing of the base.

REINFORCED PAVEMENT.

The determination of the use of reinforcement in concrete pavement will depend upon the type of foundation and width of pavement. Reinforcement may be used in either single or two-course work and is particularly designed to care for slight settlements of filled-in foundations and to guard against construction cracks developing where the pavement is wide. In any road where a new fill of over 2 ft. is made, and the material used is other than sand or gravel, the pavement should be reinforced no matter what the width of the road.

One condition often arises in towns or cities in the laying of a sewer down the middle or side of a street just prior to placing a pavement. Where such excavation is necessary, and the pavement is laid upon the fresh fill, sufficient reinforcement should be placed near the base of the pavement to give additional strength at such a point.

The type of reinforcement which is most economical in price and handling is the wire fabric. The weight of fabric to be used in this reinforcement is still an open question and must be determined to suit each specific case. Light, inexpensive reinforcing has been advocated in two-course work; the reinforcement to be placed upon, and pressed into, the still plastic base. Being slightly undulating, it insures that no line of cleavage can possibly develop between the two courses, and in addition it imparts greater strength and security to the pavement. For single course work the reinforcing is placed about 2 in. from the surface.

COUNTRY HIGHWAYS.

The advent of the motor-driven vehicle has made obsolete our "good roads" of a few years ago; no type of gravel or macadam road can stand such traffic. The cost of the better types of pavement has discouraged their use, but concrete, by providing a permanent and economical material, has solved the problem of paving country highways.

An important point in favour of permanent pavement in the country is that the farmer has the road to use in the season when he most needs it.

Gravel Shoulders.—The gravel used in the construction of shoulders should be a first-class road gravel containing sufficient clay or earth to cause thorough packing, that it may offer a substantial resistance to traffic. As the gravel shoulders are used only for the purpose of turning out, the wear will not be excessive, and the cost of maintenance will consequently be low.

ESTIMATES OF COST.

Analysis of cost must include material, mixing and placing, expansion joints, water supply, equipment and bonds.

Materials.—An analysis of the material costs of one-course and two-course work will show that the difference is so very slight as to be doubtful of estimation. However close an approximation an estimate may be, it cannot be exact, and, therefore, it will readily be seen in the following formulas that the main consideration in choice of type

Fig. 5. Showing Road in course of construction.
CONCRETE PAVEMENTS.

of pavement must necessarily be dependent upon the materials available; and the type chosen will be that to which they are best adapted. This formula is based on Thompson Taylor's Table of Proportion.

Considering: C equal cost of cement per barrel,
G equal cost of gravel per cu. yd.,
S equal cost of sand per cu. yd.

Then, for one-course work of 1 : 2 : 3 mix, 7 in. thick, the material cost per sq. yd. of pavement is $\cdot 325C$ plus $\cdot 0975S$ plus $\cdot 146G$; while for two-course work, 7 in. thick, composed of 1 : 2½ : 5 base, and a 1 : 1½ top mortar, the material cost per sq. yd. of pavement is $\cdot 342C$ plus $\cdot 1045S$ plus $\cdot 133G$.

These two formulas show the tendency to equalise the cost by small compensating differences in the several quantities, and are given here to illustrate this point.

Mixing and Placing.—With good equipment and an average gang the actual cost of mixing and placing should not exceed seven cents per sq. yd. for 7 in. of concrete. To this should be added a cost of three cents per sq. yd. for finishing and labour necessary

for handling the forms, making a total for one-course work of ten cents for mixing and placing.

Expansion Joints.—Placing expansion joints is such a simple operation that one cent. per sq. yd. should cover the cost. To this must be added the cost of metal joint and tarred felt delivered on the job, or the cost of filling the joint with a plastic filler.

Water Supply.—On city streets the water supply is not a problem; but on country highways, where it is necessary either to haul or to pipe water a considerable distance, it is advisable to make a careful survey of the situation. In estimating the cost of water the amount required for keeping the pavement damp for a period of five days must not be neglected, and as this is an indefinite quantity dependent upon weather conditions, only an approximate cost can be suggested.

The cost of hauling water for use in constructing country highways of concrete is often an item worthy of careful consideration. The method of supplying water by piping is considered by the majority of contractors as most economical. Where water is available under sufficient pressure the pipe line can be attached directly to the city main, thus eliminating engine and pump, but where water is taken from a well, creek or river in vicinity of work, an engine and pump will be required. The cost of gasoline engines varies with rated horsepower, and the cost of pumps would vary according to the capacity pressure required and the conditions under which work would be performed.

Where the construction is small, the installation of efficient pumping equipment may not be justified, in which case hauling in tank wagons can be resorted to. One-team hauling tanks having upwards of 350 gallons capacity will supply a mixer of ⅓ cu. yd. with sufficient water for a day's run, provided the haul is one and a half miles or less.

EXAMPLES.

In discussing the cost of concrete pavements, a few examples of actual construction will help to make clear the division of expense. The first pavement I shall mention was laid recently in a small town in the central part of Illinois, totalling 5,000 sq. yds. The total cost of the work was $3,964.02, excluding cost of equipment, which consisted of a ⅓-yd. Koehring mixer of the latest type and a four and a half horsepower gasoline engine, and also excluding the cost of the water for mixing and sprinkling. The pavement was 45 ft. wide and uniformly 6 in. thick. The cost of the work was divided as follows: Superintendence, $140; 1,457 barrels of cement, $1,547.15; sand, stone, and gravel, $1,284.97; labour, $560.07; lumber and forms, $35; bitumen and creosoted blocks for joints, $48.67; coal and oil for mixer and engine, $30.75; excavation, $307.41. A summation of these figures gives the cost of this road as $4.76 per cu. yd., or $.79 per sq. yd.

During the summer, Milwaukee County, Wisconsin, constructed several concrete highways to the south and south-west of Milwaukee. Data on a two-days' run from one of these jobs were collected. Twenty-four men and ⅓-yd. Smith mixer of the dumping type were able to place 94·1 cu. yds. or 470 sq. yds. of 9-ft. road 7 in. thick for a total of $364.41, exclusive of cost of grading and interest and depreciation on equipment. The materials were furnished free to the contractor on the siding nearest the work and hauled to the job at his expense.

In figuring the cost of the road, the cost of materials to the county was included with the cost of mixing and placing carried by the contractor, and are itemised as follows: 111·5 barrels of cement, $115.96; 93 yds. of bank-run gravel, $94.86; water piped from the city, $19.27; Baker protection plates for expansion joints, $29.07; coal and oil for engine, $4, and labour, $101.25, making the cost per cu. yd. $3.98 and $.79½ per sq. yd.

In the west central part of Michigan 2,586 ft. of concrete 9 ft. 2 in. wide and ·55 of a ft. thick were constructed by a township as an experiment. A gang of twelve men

using a 7 cu. ft. side delivery Koehring mixer did the work for a total cost of $3,392.62, divided approximately as follows: 746 barrels of cement, $870; 655·9 yds. of sand and gravel, $553.28; Baker protection plates and filler, $170.12, and labour, $1,690.50. These figures give a cost of $7.28 per cu. yd. or $1.31 per sq. yd. Had the cost of grading, excavation and culverts been added to the above, the cost of pavement would have been increased to $8.73 per cu. yd. or $1.46 per sq. yd.

CONCLUSION.

In conclusion, a few words further explaining one or two of the illustrations may not be amiss. *Fig.* 1 shows the pumping equipment used for concrete road construction, with the gas engine ready to be belted to the pump.

In *Fig.* 2 the finishing bridge is shown in the foreground, and in the background the strike boards and mixing equipment can be seen.

Fig. 3 illustrates how, after the concrete has been mixed, it is dumped into a bucket, and carried on a long boom, which swings over a length of about 18 ft. The view in this illustration shows the concrete in the position required, and in the act of being discharged from the bucket upon the sub-base.

The steel protection-plate shown in *Fig.* 4 is laid up with two thicknesses of $\frac{1}{8}$-in. tar paper between. After being placed in the pavement the clamps are removed, and when the concrete has hardened the anchors serve to hold the plate in place, the tar paper making provision for subsequent expansion.

Fig. 6. View of a Finished Concrete Road in U.S.A.

CONCRETE PAVEMENTS

RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

THE CONCRETE INSTITUTE.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

THE STRENGTH OF CEMENT.

RESULTS OF TESTS ON FIFTEEN DIFFERENT BRANDS USED IN PASTE, MORTAR, AND CONCRETE.

By H. C. JOHNSON, Demonstrator in Engineering, University College, Cork.

The following is an abstract of a Paper read at the Thirty-fourth Ordinary General Meeting of the Concrete Institute.

To many people it is, undoubtedly, a fact that any bag marked "Portland Cement" is just as good value as any other bag so marked, and also that—

(*a*) The cheapest cement is the most economical to use.
(*b*) Testing a cement with a "name" is unnecessary.
(*c*) The value of fine grinding is not considered, even if its advantages are known.
(*d*) The paste tensile seven days' test is quite sufficient guide to a cement's value as a "binding" material.

That these conclusions are erroneous, the author will not be the first to point out.

The results of these tests are put forward with the object of calling further attention to the importance of testing all materials entering into constructional works, in which they will be called upon to do their duty, with a predetermined factor of safety. This factor, if due attention be paid to excellence of materials in every particular, may reasonably be reduced from the customary four or six to three or four and a half.

The term "paste" here used means neat cement and water. The term "mortar" means one part cement to three parts standard sand, and water.

All the specimens were tested by the author in the Engineering Laboratories of University College, Cork.

GENERAL TESTS.

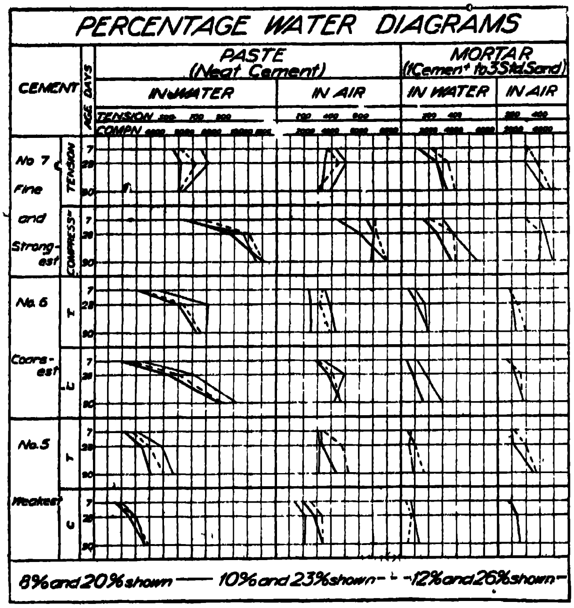
The author reported on some general tests made by him with some fifteen specimens of cement, and he gave full tabulated details of these tests. In making them, the author stated he had used rather higher percentages of water than the British Standard Specification requires. The cement tests comprised tests for fineness, apparent density, and specific gravity. Some tests for setting times were made, but were not included, but most of the samples might be termed "slow setting." The cement paste was submitted to tension and compression tests. Some tests with cement mortar demonstrated clearly the value of fine grinding, and the superiority of the mortar test over the paste test as a guide to the binding value.

PERCENTAGE-OF-WATER TESTS.

Three of the cements used in the general tests were here employed—namely, the cement which had proved the finest and strongest (No. 7), the coarsest (No. 6), and the weakest (No. 5).

The following points are worthy of attention in connection with these tests:—

1. A decrease in strength in tension at ninety days as compared with twenty-eight days does not necessarily indicate a decrease in compression.



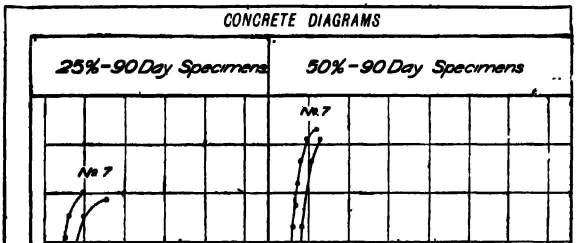
2. At ninety days the difference in strength between the specimens with the high and those with the low percentages of water is very small—in the case of the air-cured specimens it seems an advantage to have a higher percentage of water.

3. A low percentage of water would allow an inferior cement to pass the British Standard Specifications, whereas even 26 per cent. in a good cement would not prevent its passing.

4. The higher percentages of water have a greater effect on the tensile strength than on the compressive.

5. In the paste specimens at ninety days the 23 per cent. of water gives 42 per cent. of the high results, showing that all cements do not give their greatest strength with the minimum amount of water it is possible to use.

6. While the low percentages of water give a higher strength at the earlier ages, in the majority of cases there is very little falling off at ninety days, due to the increase of water. In fact, one might reasonably expect that with a good cement the higher percentages would eventually produce a stronger material.



On comparing the cements, No. 6 (the coarse one) is heavier on the whole per specimen in paste than either Nos. 5 or 7, besides absorbing less water than No. 7. This is because it is more dense on account of the variety in the size of the particles.

In the mortar the positions of Nos. 6 and 7 are reversed, No. 7 being the heavier because the finer particles allow the sand grains to lie closer, whereas the coarse material in No. 6 spreads them, and while it produces a greater amount of mortar, it decreases the strength because the final percentage of voids in the whole is greater than mortar composed of the finer cement.

The author pointed out the advantage of testing with higher percentages of water than those now generally used, with the idea of weeding out the poor cements.

That air-cured as well as water-cured test specimens might, with advantage, be made when endeavouring to find the perfect cement seems to be indicated by these tests.

The tests also show the importance of keeping cement or concrete moist during the early stages of curing.

CONCRETE TESTS.

For the purpose of these tests the author used 6-in. concrete cubes, and here again cements No. 5 and 7 were employed, and as the supply of the coarsest (No. 6) had run out, two intermediate cements from those used in the general tests were used with the idea of obtaining four different strengths.

The coarse aggregate was crushed, hard limestone passing the ¾-in. and retained in the ⅛-in. sieves, and had 40 per cent. of voids, found by pouring water into a ⅓-cu.-ft. bucket full of stone (the voids found later by specific gravity method equalled 42 per cent.). The fine aggregate was a fair quality sand which passed the ⅛-in. sieve, but ran to quite fine, and had actually 38½ per cent. voids (found by pouring sand into the ⅓-cu.-ft. pail and noting the water displaced), but was considered, in proportioning, as having the same as the stone.

All aggregate was washed about six hours before used and drained during that period.

These test specimens were not treated with special care in tamping or curing, the temperature of the room varying between 55° and 65° F., that of the floor on which they were laid, being of stone, might have dropped to 50° F. on occasions. The strengths are not high, mostly accounted for by the use of the poor sand and hard limestone; however, this does not in the least affect the value of the tests as showing the varying strengths of different cements, since the mixtures were the same in each case.

Referring to the concrete diagrams, in which readings of the deformation were taken in most cases up to the ultimate load, another and a more important point is brought out, speaking now from a reinforced concrete point of view, and this is the splendid, long-continued, initial modulus of elasticity that a good cement will give, indicating how high a factor of safety is obtained when the working stress is limited to 600 lb. per sq. in.

CONCLUSIONS.

From the detailed results of his experiments the author drew the following conclusions :—

1. That a good strength in paste is no proper indication of a good strength in concrete.

2. That the best tests of a cement's value for reinforced concrete or similar work are—

(a) Mortar compression cured in water,
(b) Mortar compression cured in air,

and, in addition to having to show a certain strength, any cement having a higher value in air than in water to be condemned.

3. That not less than 22 per cent. of water be allowed in gauging paste, and not less than 3 per cent. plus ¼ the percentage as used in the paste, in gauging mortar.

4. That the standard of values for cement to be used in reinforced concrete work be raised by 25 per cent.—not that a cement only just passing the British Standard Specification is to be condemned for average work, but in order that first-class cements only shall enter into reinforced concrete structures; engineers may then reasonably expect to be able, in the near future, to use 1,000 lb. per sq. in. on concrete instead of 600 lb.

5. That for a given expenditure on cement a first-class one will allow a saving, since there will be—

(a) Less cement to pay carriage on,
(b) Less cement to handle,
(c) Less sacks to clean, tie up, and return,
(d) With at least as strong a concrete.

6. That a given strength of concrete should be specified, instead of a given mix—which does not take into account the proper proportioning of aggregate—even if a cement of first quality is used.

7. That cement should be sold by volume instead of by weight, and in bags contain-

ing 1 cu. ft., to allow of quicker and easier handling. These bags should be made of paper for preference, this being the common practice in the United States. Among the advantages the author noted that paper bags have over canvas ones are—

(*a*) No time is lost in shaking out the cement,
(*b*) No cement is retained by the sacks,
(*c*) There is no return freight on empties,
(*d*) The packages are better looked after in storage, and
(*e*) Cement is kept in better condition.

DISCUSSION.

Mr. D. B. Butler, Assoc.M.Inst.C.E., F.C.S. (Member of Council C.I.), said he did not agree with the author's opinion that testing cement with names is unnecessary. He also was not in accord with the author on the subject of the 7 days' neat tensile test for determining the value of cement for certain purposes. Also the author persisted in using the word paste. Paste seemed scarcely the true definition for neat cement tests. In the paper it is said that the neat tensile test is insufficient. Of course, by itself it is not sufficient. In testing cement he always asked himself, is it constant in volume? is it at all likely to expand after, say, a month or three or four months and cause trouble? These are the first points to consider, no matter what other quality cement may have.

The main thing contended throughout the paper is the percentage of water used for testing, for making up the paste, and the author admitted that all his paste tests were made with a much wetter consistency than that advocated by the British Standard Specification, and the amount of water used was such as to make the cement equally plastic on the slab. He (the speaker) had always advocated that in testing cement in a laboratory test the idea is—unless there is some standard to go upon—to find out what that cement is capable of under the best conditions; and, therefore, the idea of testing cement is to obtain the best results compatible with certain conditions which custom has laid down as a fair test. He did not agree in using the very driest possible mixture and putting it under pressure to get a solid briquette; that was going too far, but he fully agreed with the British Standard recommendation that the briquette should be made so that the consistency should be such that when the paste or the mixture is put into the mould it becomes plastic; when it is rammed into the mould it becomes plastic.

In Germany it is the custom to make the briquettes extremely dry and to hammer them in with a mechanical hammer, thereby giving a much higher strength than would be done by what the French call making a liquid mass and pouring it in. The author apparently attributes considerable value to the specific gravity of cement; his own opinion on that point was that, given a proper artificial Portland cement free from adulteration, specific gravity is not worth much. The specific gravity, as a rule, is intended to show, apart from adulteration which can be detected by other methods, originally the amount of calcination to which the cement had been subjected in the course of manufacture, but he had personally made a considerable amount of research on that point, and his experiments had conclusively shown that the specific gravity of unburnt clinker and of well-burnt clinker was identical at the moment at which that clinker emerged from the kiln, so that the difference in specific gravity is almost entirely due to water and carbonic acid absorbed by that clinker or by that cement after burning and grinding, and moreover that the specific gravity of the yellow unburnt clinker, as it came from the kiln, would pass the British Standard Specification for good cement.

Mr. H. J. Harding, M.C.I., raised some questions in connection with the compression tests. He understood that the sand was taken on the void and the quantity of cement was arrived at in accordance with the void. He wished to know whether the sand was taken in its very dry state, for this would make a considerable difference. He had found from experience that an average sand—say, Thames sand or sand of a similar nature—that taking a measure of, for example, a cubic foot, or any measure, it could only be filled by about 5 per cent. more than if the sand were perfectly dry. He wished to show the sand between these two points. Assuming a measure, like a horseshoe, on one side is put the consolidated mass in water, and on the other side a perfectly dry cement consolidated by its own dryness, say, like an hour glass. When the cement is put in for all these compressive tests they arrive at a point between those two. In speaking of the void, the one giving the greatest void would be about three parts from the consolidating in water, and about one part from the point of consolidated dry. That is a fact of very great importance in making these tests, because the voids increase and more cement is needed to fill up those voids, and consequently there is a greater amount of cement in proportion to the sand. The same thing comes to perhaps a little less degree in concrete with the other ingredients.

Mr. H. K. Dyson (*Secretary*) said he would like to corroborate the statement of Mr. Harding, that the voids in sand do depend a great deal upon the percentage of moisture that there is in the sand. There is generally a gradual increase in the percentage of voids in sand, with the addition of percentage increase up to 5 per cent. increase on the dry sand, and after the 5 per cent. increase is attained, as a rule, the sand continues at about the same volume until about 10 or 12 per cent. is reached, when the sand begins to get thoroughly saturated, and it then begins to drop back again, but with a very slight increase in the percentage of water. The dry sand and thoroughly wetted sand are approximately of the same bulk, but the increase by the addition up to 5 per cent. of water is generally about 5 up to 25 per cent. increase in bulk, dependent, as a rule, on the cleanliness of the sand. This refers to the amount of loam or other similar matters that are in the sand. With standard sand it is about 15 per cent. increase—10 to 15 per cent. increase—for 5 per cent. addition of water. The majority of sand when bought, even when dry, contains 1 or 2 per cent. of moisture. That is permanently in it, and can only be dried off by heat. But the sand that is purchased in practice has about 3 or 4 per cent. of moisture, so that the bulk is about 10 per cent. greater than when it is thoroughly wetted. In the making of concrete when it is tamped in position, the tamping in position also makes a difference. If 5 per cent. of water be added and it is then tamped the bulk can be reduced by continued tamping; in fact, the question of tamping makes a considerable difference in the proportion of concrete, because the ordinary coarse material, if tamped sufficiently, makes a dense concrete without the addition of any sand whatever; it depends solely upon the amount of labour, and in proportioning concretes, adding sand and determining voids and so on, one needs to take into account the amount of labour that is going to be put in in practice. The reason for using a fair amount of water and an amount of sand in concrete is simply to save in labour.

The Chairman: Mr. Butler raised some very important points with regard to the inadequacy of the specific gravity as a test of quality. Another important point was raised by the author himself in which he recommended that cement should be purchased by volume. It appeared to him that the weight is a thing which one cannot very easily alter, and as far as ordinary chemical processes go weight is that one thing which we do not alter. Everything else is changeable. And it appears also that the volume of cement is almost governed by the distance travelled. He felt that selling by weight is the only way that can give general satisfaction, and it is also probably the only way in which uniformity of results can be guaranteed, because doubtless the great diversity experienced has often been due to the differences in what was supposed to be a cubic foot of cement.

Mr. Noel Ridley: Cement should be bought by weight. There was no other way. He agreed with Mr. Butler that it is an advantage to have the cement tested wherever possible, but there is one advantage in accepting a name, and that is that one is more likely to get what one expects than from a cement without a name. In practice it is sometimes necessary to use cements before they can be tested. In fact, there is no opportunity in many cases of making a test, and therefore a name is a very important thing.

It was announced that the author would reply to the various points raised in the discussion in the Transactions of the Institute.

PROPS AND BEAMS IN MINES.

By S. M. DIXON, M.A., M.Sc., M.Inst.C.E., M.C.I., Professor of Civil Engineering at Birmingham University.

The following is an extract from a paper read at the Thirty-fifth Ordinary General Meeting of the Concrete Institute, Mr. E. P. Wells, J.P., President, in the Chair. A short summary of the discussion is also given.

REINFORCED concrete is very little used underground, and doubtless there are economic reasons for this, but the use is growing, and doubtless within a few years the employment of reinforced concrete in mines will become more general. Its use for pit-head works, such as bunkers and hoppers, and in a few mines in Great Britain is on the increase, some of the principal pits being Baggeridge, near Dudley; Sneyd, near Stoke-on-Trent; and Tunnel Pit, Haunchford, near Nuneaton.

Plain concrete is not used in mines to the extent which engineers who work above ground would anticipate.

The ingenious methods of using timber, one of the most valuable materials of construction even now, have been so successful in the past that it may need a good deal of argument to convince the mining engineer generally that even in some cases a

comparatively new material like reinforced concrete may be an economic and useful substitute.

Of course, it is only in main roads and permanent work in mines that it is anticipated there will be any extensive use of reinforced concrete work. The method of using timber in these places is well known. The roof is supported on head trees, the ends of which are carried on props, which, sloping outwards at their feet, are also used to carry, when necessary, the sides of the heading. While therefore, within limits, the top and sides of the heading are supported, under considerable pressure the floor must be continually rising, and thus requires continual attention, while gradual settlement of the whole heading takes place.

The strength of the timbers used in mining is fully discussed in a paper by Professor Louis, and he states that the strength of larch props is 3,360 lb. per square inch, and Scotch fir is 2,688 lb. per sq. in., when the timber in each case is thoroughly seasoned, dry, and also fully grown, while the strength of wet timber was from 40 to 50 per cent. less.

It is evident that frequently in mines the props and beams will be wet, and therefore, according to these figures, the existing strength of a larch bar should not be assumed to be more than 1,780 lb. per sq. in., which will certainly be less than a well-made reinforced concrete post four months old. Besides, in a mine dry rot quickly attacks timber unless constantly wet.

The cost of timber for mine-work is continually increasing, the price of foreign timber having risen as much as 45 per cent. during the last five years.

In arranging a preliminary set of experiments on the strength of beams and posts of reinforced concrete for mine work, it was decided to compare the results obtained from specimens of three different cross-sections for the posts, viz., square 8 in. by 8 in., round 8 in. diameter, and triangular 8 in. side, and also to vary the reinforcement both in percentage and in method of arranging it. The cross-sections of the beams were (*a*) 8 in. by 12 in., (*b*) triangular 8 in. side. If the beams are to be made and stored before use and afterwards transported to the mines, it is evident that they must have some reinforcement near the compression side for safety in transit, and it may be ultimately more economical to use some particular shape and similar reinforcement both for props and beams, the lack of economy in design being more than counterbalanced by economy in manufacture, and the advantage of having one form of structure only in the mine. In making the test specimens, wooden forms were used for the square and triangular sections and steel forms for the circular sections. The beams were filled horizontally and the columns vertically.

TABLE I.

Influence of Amount of Water in Strength of Concrete.[1]

Per cent. of Water.	Age in Days.	Average Compression Strength. Lbs. per sq. in.
6	38	1,247
6	64	1,543
6	121	1,350
8	37	791
8	66	1,253
8	132	1,260
10	35	390
10	64	750
10	130	1,010

[1] Dixon and Villiers, *Inst.C.E.*, clxxxv.

All the concrete used was of the same composition, and was made under as similar conditions as possible. The proportions selected were 1 : 2 : 5. These proportions were chosen as being good enough to give a fairly strong concrete, and because a considerable amount of work has already been done in the Laboratory of the University of Birmingham during the last few years in concrete of these proportions. The sand was from Leighton Buzzard, and the gravel was well screened between 1 in. and $\frac{1}{4}$ in. Tests of the materials used were made from time to time, and special efforts were made to mix the concrete and ram the moulds under the normal conditions obtaining in

practice. The concrete was mixed wet; that is, with about 8 per cent. of water, experiments having been previously made on the effect of varying the amount of water in this concrete. The results are given in Table I.

These results seem important, since in most reinforced work wet mixtures are required, and till the concrete is over two months old the consequent diminution in strength is very serious. The cement was slow setting and uniform in quality.

All the tests on the beams and posts were carried out at the age of two months. About a hundred cubes of concrete 6 in. by 6 in. by 6 in. made the same time as the beams were tested at two months, and gave an average compressive strength of 1,600 lb. per sq. in. And another series of these blocks were made in order to determine the increase of strength with age for this concrete. The results obtained were very low when compared with the records given from tests on concrete blocks made at Vyrnwy, and also with the high-compression stresses given from American tests.

Tests of Beams.—In testing the 12-in. by 8-in. beams the supports were 7 ft. 6 in. apart; the load was applied at two points 3 ft. 6 in. centre to centre in the method usually adopted. Table II. shows the result of the preliminary tests.

TABLE II.

Tests of Reinforced Beams, 8 ft. × 1 ft. × 8 in.

No.	No. of Specimens.	Reinforcement. Kind.	Per cent.	Breaking Load. Equiv. uniformly distrib. load. Tons per lineal ft.	Method of Failure.
1	3	2 Straight ½ in.	0·45	1·0	Tension
2	3	2 Straight ½ in. ... ... 1 Bent up ½ in.	0·67	1·3	Diag. tension
3	3	1 Straight ½ in. ... ... 2 Bent up ½ in.	0·67	1·1	Plain and diag. tension
4	3	1 Straight ½ in. top ... 1 Straight ½ in. bottom 4 Bent up ½ in.	1·34	1·4	Diag. tension

Tests of Posts.—In making the posts for these preliminary experiments, only one rod was used for reinforcement in each case, and the rods were only 7 ft. 8 in. long, thus leaving 2 in. of concrete at each end, so that the rod did not come in contact with the crushing plate of the machine. The only reason for reinforcing the posts is

TABLE III.

Compression Tests on Square and Round Posts, Concrete Plain and Reinforced, 8 *ft. long.*
(*Age of Concrete* (1 : 2 : 5) 2 *months.*)

No.	No. of Tests.	Section.	Reinforcement.	Crushing Load. Lb. per sq. in.
1	2	8 in. × 8 in.	(Plain)	1,270
2	2	8 in. × 8 in.	1, ¾ in. × ¾ in., 7 ft. 8 in. long	1,266
3	2	8 in. × 8 in.	1, 1 in. × 1 in., "	1,300
4	2	8 in. diam.	(Plain)	1,234
5	2	8 in. diam.	1, ¾ in. diam., 7 ft. 8 in. long	1,020
6	2	8 in. diam.	1, 1 in. diam., "	1,068

to make them portable, as it was considered that the crushing strength of the concrete would be ample for it to work, provided that it could be developed. It was anticipated that economic reasons would prevent the use of spirally reinforced concrete columns of such small dimensions. As was expected, the square columns gave better results per square inch than the round columns.

Table III. shows the results of tests on the first set of posts made.

Tests on sixteen posts of triangular cross-section and eighteen beams show similar results, which, however, cannot be exactly compared with the above, since by a mistake the proportions were not exactly the same, the mixture being a little richer in cement.

The results show, however, that there is no difficulty in making, storing, and

transporting suitable beams and posts of concrete whose proportions are even as poor in cement as 1 : 2 : 5.

The author quoted numerous examples where reinforced concrete had been used in mine work, and concluded by stating that it seemed evident that reinforced concrete will have an extended use in the future for main roads when the pressures are great.

The President, before opening the discussion, read a letter from Mr. Frederick Purton, in which he described some reinforced concrete work recently carried out at the Planmeller Collieries, Haltwhistle, Northumberland. The work comprised the lining of two new shafts.

Instead of the usual brick lining, segmental slabs of concrete reinforced with expanded steel were used.

The lining of the shaft with such slabs was completed to a depth of 12 fathoms some time ago, and it has since been used under ordinary working conditions.

It has been found to be so economical in construction, and has proved so satisfactory in use, that further lining of a similar nature is now in progress.

DISCUSSION.

Mr. E. Fiander Etchells, F.Phys.Soc. (Member of Council C.I.), said that he thought the future of reinforced concrete in mines was altogether uncertain, and nothing but time can tell whether it is really the fittest material.

He went on to ask one or two questions regarding the reinforcement of the triangular beams and the 8-ft. pillars tested.

With regard to the pillars, he thought a striking feature of the result of the tests was the way in which the fractures occurred at the ends of the pillars. This is the normal method of failure, and it is rather an indication that it is the right thing to do in all cases of pillars, to put the heaping or the laterals, or the binding, closer at the ends of all reinforced pillars, in fact, he suggested that a good rule to adopt would be to make the binding twice as close at the ends as it is in the middle of the pillars.

With regard to a quotation from Professor Louis, in which the Professor states that a prop has the same strength whatever its length, under the ordinary conditions of practice, he thought it should be pointed out that the statement may lead inexperienced designers to neglect the ratio of length to diameter.

Mr. S. S. Roberts said his experience had been more among gold mining abroad rather than coal mining. He had often thought that reinforced concrete could be used in underground work for setts. The difficulty that had been uppermost in his mind was that concrete lost its nature in the tropics. But if props could be successfully manufactured and used soon after construction they would be valuable in gold mining and even in main roads, especially if the difficulty of upward pressure through soft ground could be overcome.

Mr. W. Cyril Cocking, M.C.I., after raising some points regarding a slide showing a loaded beam, cracked in the centre, went on to say that he thought that in mine work all the materials should really be made above ground, and the pieces should be made in such a way that they are all interchangeable, that is, the beams should be reinforced in a similar way to the pillars, and some simple connection should be made so that the pieces can be easily removed and connected together as the work goes along, and as regards the position of the beams and posts, they should be made similar to the construction of an ordinary reinforced concrete pillar, where there are four rods, which would be the same as four sills, two along the bottom and two along the top, and then lastly reinforcement would be pillars and cross-beams, and in between those beams, along the top, and pillars along the side, and the secondary beams or slabs could be fitted in, and so save any centering, and work which would take some time before the centering could be taken down and the tunnel used.

Mr. H. Lee mentioned that he knew of a shaft being sunk abroad in a colliery, and lined with concrete. It was not reinforced in any way, but it was about 6 in. thick in the minimum thickness, and the shaft was about 700 ft. deep, and it has been sunk now for about four or five years, and is a great success.

Mr. E. P. Wells, J.P., President, said he thought that it would be a most difficult matter to design reinforced concrete work so that it could be used in mines under all conditions. As a rule, it is often necessary, of course, to strut at a very, very short notice, and reinforced concrete would have to be made of so many different lengths that he doubted very much whether it would ever be found to be economical, especially in this country. With ordinary props, if it is necessary to cut them [illegible], it is easy to do so, and it is also easy to wedge up. That, of course, can be done with reinforced concrete, but until some method can be designed that would make it cheaper than timber, assuming that timber, when wet, has a life of about 15 to 20 years, he did not see very well that anything could be done in the matter. But when

working in a dry ground, and it is fairly good, and not soft, something might be done with concrete, especially where it can be constructed *in situ*.

With regard to the experiments which have been carried out by the author of this paper, he noticed especially the very weak mixture of concrete that had been used for experimenting, namely, 1 to 3 to 5. He thought in a case of this kind, if richer mixtures had been employed, it would have paid, and that the results would have been very, very different from those obtained.

With regard to the tests for columns, his opinion was, that with good rich concrete, and a column well-made, if it is allowed to harden on age, after twelve months' time it will, in every instance, simply carry more than the one that is reinforced. But, of course, the concrete must be good. With a weak concrete, and reinforced, the reinforcement will carry very much more, but with a rich concrete the plain concrete column will, there is no doubt, carry more load if the test is carried out satisfactorily, that is in a vertical position, not in the horizontal, where, in nearly every instance, a slight bending moment is put into the column.

PROFESSOR DIXON'S REPLY.

Professor Dixon, in replying, said he was quite certain that reinforced concrete was only for use in mines in special cases, but it had been used. The use will go on, and only in main roads. As the President has said, in the ordinary case one is continually cutting off the props in order to get them the right lengths. But main roads are made certain heights in mines, and in that case it may be found useful. He had never heard of reinforced concrete in mines.

The President criticised the weak mixture, but people are accustomed to putting in very weak mixtures sometimes. The first work he remembered working on was the retaining walls at King's Cross Station, just by the tunnel. In that case the concrete was specified by the Great Northern engineers, not with the proportion of sand, but as 1 to 9. It was 1 part of cement to 9 parts of Thames ballast, and those walls outside No. 3 Tunnel are there still.

Regarding the question asked by Mr. Etchells as to the reinforcement of the triangular beam, the only reason for using a triangular beam is that of all shapes it is the easiest shape to make in practice. In making these forms only a trough is required, and in all these cases of forms one has to think not only what would be absolutely the best to design, but what would be commercial forms as well, and he thought in many cases it might be possible to use even the same shaped thing for a beam or for a post.

Replying to Mr. Cocking's remarks as to the beam cracking in the centre. There is, of course, a uniform bending moment, owing to the weight that is applied, but owing to the weight of that beam, there is a greater bending moment at the centre, and so there would be a tendency for the beam to break there. Experiments carried out on continuous beams do not show an exact agreement between the practice and the theory.

NEW WORKS IN CONCRETE
AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE FLOORS AND FLATS IN THE NEW POLICE STATION AT GOODWICK.

THIS building, which has just been erected, has a frontage of 46 ft. and a depth of 60 ft., occupying practically the whole of the site, which was a very awkward one, with a fall of 19 ft. from front to back.

The floors and flats are of hollow coke breeze blocks reinforced and put together in accordance with the Hennebique System; the main staircase and the beams carrying

THE NEW POLICE STATION, GOODWICK.

the cell walls are of reinforced concrete, as are also all lintels. The basement floor, yard paving, and the external flight of steps are of Granolithic paving.

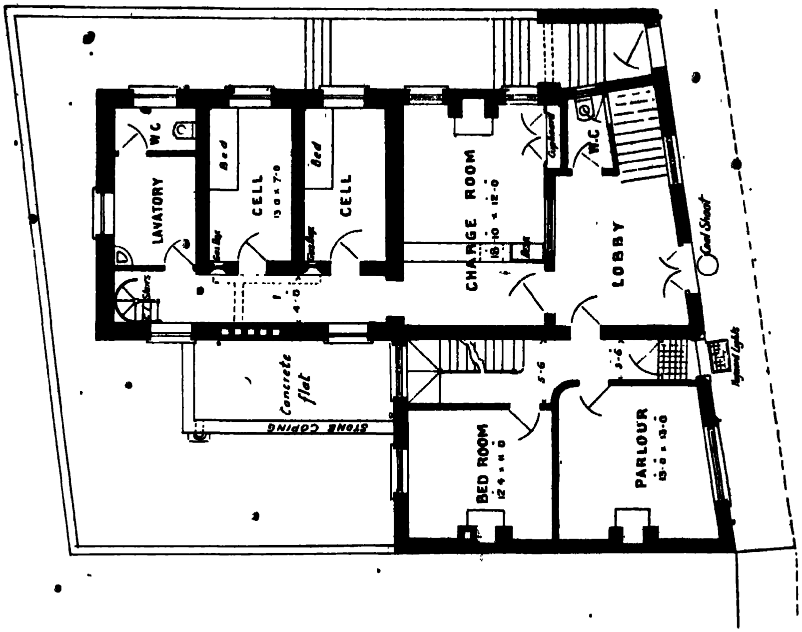
The accommodation provided is a sergeants' house of eight rooms and conveniences, a "lock-up," a sessions room, single constables' quarters, etc.

The first-mentioned is situated on the left of the front, while on the right-hand side is the official part, which comprises, on the ground floor, a commodious entrance lobby giving access to the charge-room, from which, in turn, there is an exit to the cell corridor, and from thence to the cells.

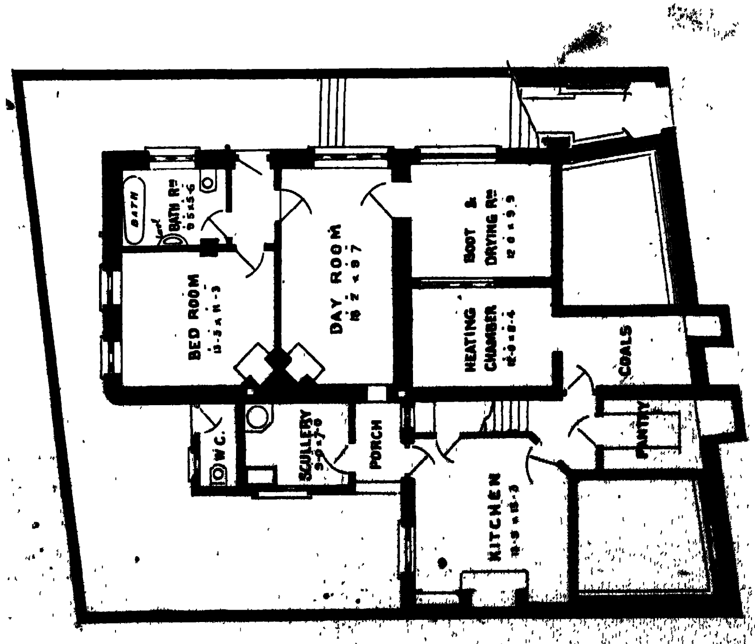
From the corridor a circular iron staircase leads to the sessions room above, for the use of the prisoners. This apartment, on the first floor, is approached by the public from the entrance lobby by means of a granolithic staircase. In addition to this room, with its fittings, dado and ceiling of pitch pine, and ample and effective lighting, there

is provided a magistrates' retiring room and witnesses' room, each replete with the necessary conveniences and heated by means of radiators and piping.

Full advantage was taken of the fall in the ground and, as it were, a lower ground



Ground Plan.

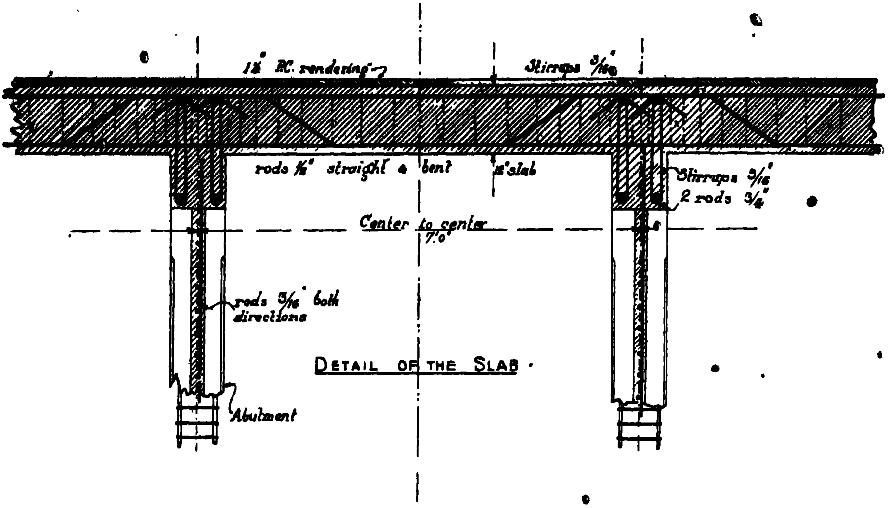


Basement Plan.

The New Police Station, Goodwick.

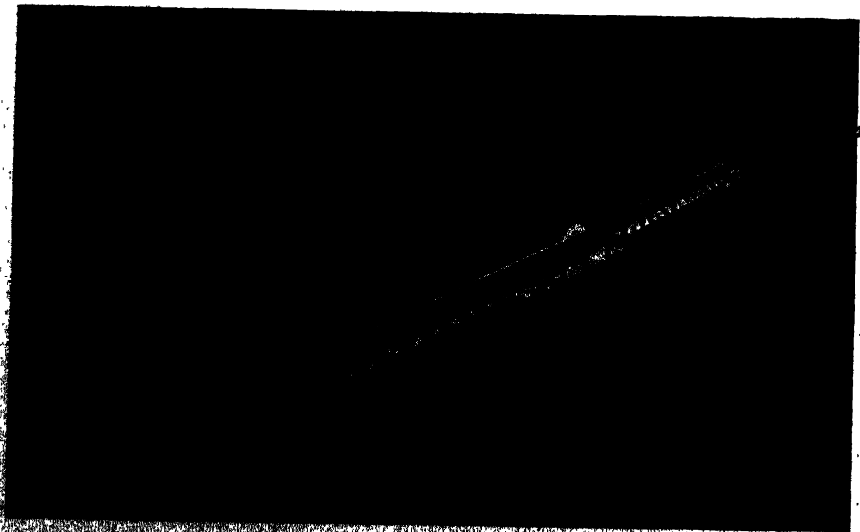
floor was provided, in which was placed, quite distinct from the other portions of the building, the single constables' quarters, approached by an open side passage.

The heating chamber is situated in the centre of the building, the fuel room being served by a coal shoot in the front pavement.



REINFORCED CONCRETE DAM, HONGAY.

The builders were Messrs. Cole & Sons, Milford Haven, the reinforced concrete work, granolithic paving, and asphalting to the flats being executed by Messrs. Hobrough & Co., Gloucester.



REINFORCED CONCRETE DAM, HONGAY.

The heating is on the low-pressure system, and was done by Messrs. Legg & Co., Swansea.

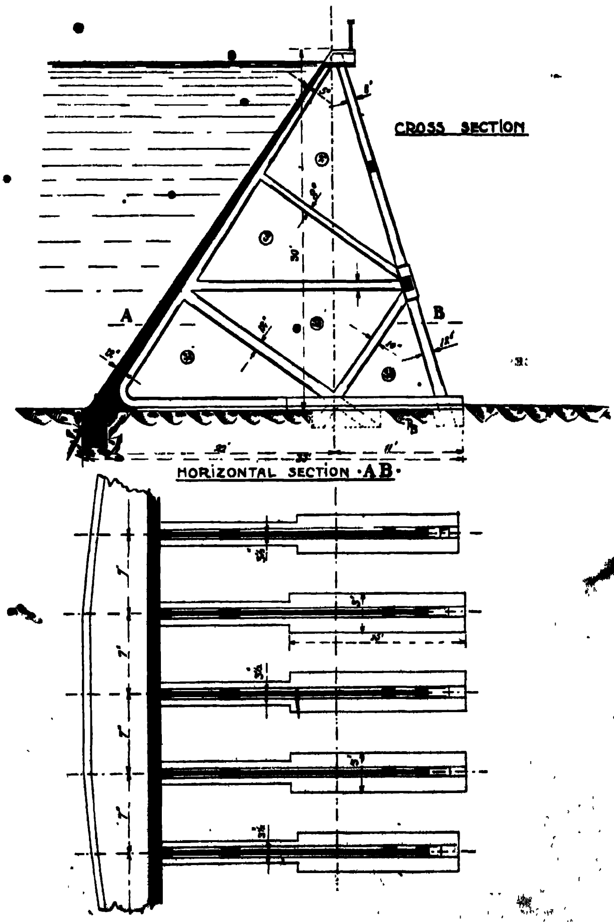
The building, which is one of the most up-to-date in the Principality, was designed by Mr. Arthur [illegible] Thomas, A.R.I.B.A., County Surveyor.

REINFORCED CONCRETE DAM AT HONGAY, FRENCH INDO-CHINA.

The dam, of which we give a description below, has been designed and built by Mr. P. H. Barriere for the Société des Charbonnages du Tonkin, Hongay.

It retains a total quantity of about eight million gallons of water, the greatest height at the centre being 30 ft. and the total length 160 ft.

As shown in the drawing, it consists of a continuous reinforced concrete slab making an angle of 55° with the ground level, its thickness being 1 ft. at the base and 5 in. at the top. It rests on a series of buttresses 7 ft. apart in the form of reinforced concrete triangle frames, the different parts of which are bound together by a vertical slab 3½ in. at the bottom and 2 in. at the top. The principal strut carries the resultant pressure of the water to the ground, where it is embedded in the rock, as also the base of the inclined slab.



Reinforced Concrete Dam, Hongay.

The outside face of the inclined slab was rendered in cement 1½ in. thick, and has been found quite waterproof.

The inclined slab has been designed with round bars top and bottom reinforcement and bent bars, with $\frac{wa^2}{24}$ and $\frac{wa^2}{12}$, which formulæ have been found sufficiently safe, the measured deflections of the slab being practically *nil*.

The native labour available was entirely unskilled as regards reinforced concrete.

The structure was designed in competition with designs to be carried out in plain concrete and masonry.

We believe the above dam to be the first executed entirely of reinforced concrete in the Far East.

AN ARTISTIC CONCRETE BANDSTAND.

The accompanying photograph shows an artistic concrete bandstand erected in the village of Clyde, N.Y. This bandstand is located in the park, and is a good example of concrete block construction, and was designed by Mr. E. W. Dickie. It is octagonal in shape, and the foundation is 4 ft. in depth, 2 ft. in width, battered to 12 in. on top. The concrete mixture is 1 : 2 : 4, with four courses of concrete blocks.

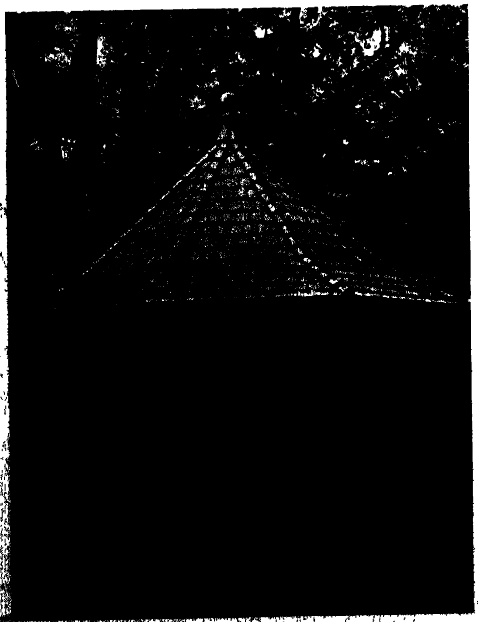
There is a 2-ft. pier in the centre, the floor being 20 ft. in diameter and constructed of reinforced concrete. The reinforcement consists of 3 in. by 6 in. expanded metal, with cross rods 1 in. by 3 in. on 2 ft. centres and expansion joints.

It may be stated that the pedestals, caps, rails, spindles and columns are of

concrete with monolithic base, 6 in. shaft, 3 in. at bottom and 7 in. at top. The roof is of clay tile on wood frame, 9 ft. from floor to ceiling. The bandstand is of Doric

REINFORCED CONCRETE DAM, HONGAY.

architecture, a hard pine ceiling being utilised, with concrete steps made in place, and 4 ft. foundation. All the concrete work was made in the contractor's shop and allowed to cure thirty days before placing.



CONCRETE BANDSTAND, CLYDE, N.Y.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

"Reinforced Concrete Bridges." By Frederick Rings, M.S.A., M.C.I., C.E.

Published by Constable & Co., 10 Orange Street, Leicester Square. Price 21/- net. Size 11 in. × 7½ in. 181 pp.

This book has been written to supply information as to the most important features of bridge design, and contains information which would be of service to those requiring practical help in the examination of designs of bridges and arched structures generally.

Chapter I. gives Practical Hints on general questions of design, and gives a full reprint of the draft regulations of the London County Council with respect to the construction of buildings wholly or partly of reinforced concrete.

Chapter II. deals with Bending Moments and Shearing Stresses, and gives particular cases of the application of Clapeyron's Theorem to continuous beams of two, three, and four spans.

Chapter III. deals very briefly with Loads, Wind Pressure, and Temperature Stresses.

It is not stated why the weight of a crowd in a town should be taken at 140 lbs. per sq. ft., and why in rural districts the load of a crowd of people may be reduced to about 110 lbs. per sq. ft.

In addition, it is noted that in town bridges a concentrated load of 25 tons must be allowed for vehicular traffic, and for bridges in rural districts the concentrated load of 12 tons only is allowed. Are the laws of gravity modified in rural districts, or are lives less precious there?

May it not be desired to carry a heavy boiler or transport a heavy gun from one town to another across some rural district?

In these days of heavy motor traffic between main towns the allowance for heavy concentrated loads should depend upon the character of the road and not upon the question whether the concentrated load is concentrated in a rural or an urban area.

Chapters IV. to VI. deal with culverts, beam bridges (as distinct from arched bridges), and calculations.

Chapters VII. and X. give examples of many of the famous reinforced concrete bridges of the world (chiefly Continental).

There are many excellent folding-plates. These parts of the book will be most helpful to all persons faced with practical difficulties of design, inasmuch as the drawings of actual bridges give many hints as to how the common difficulties have been surmounted by the engineers and contractors responsible for the design and execution of the work.

Chapter XI. gives some formulæ, notes, and sundry tables.

The author has generally adopted the Standard Notation, introduced by the Concrete Institute, but it is to be regretted that in translating the investigations of Prof. Melan and others the author or translator has translated the letterpress, but not translated the symbols in the equations. (See, for example, page 92).

This species of semi-translation is one of the most prolific causes of chaos in the matter of notation.

Chapter II. (dealing with Bending Moments, Stresses and Strains) is remarkable for the fact that most of the definitions are unusual or inadequate or otherwise startling—for example, it is stated that "the *outer forces* acting on a structure causing a movement in its component parts are called *stresses*, while the *inner forces* resisting that movement and tending to hold the component parts in equilibrium are called *strains*.

The neutral *axis* is defined as a *layer of fibres*.

"Shearing *strain* is the action of two forces *at right angles* to the fibres of the piece."

One wonders why shearing strains only act at right angles to the fibres, and also whether the "actions" would still be shearing strains if the material were like concrete—*i.e.*, non-fibrous.

Moreover, these two parallel forces would appear to be external forces, and should therefore be defined as stresses. Thus the author would be able to prove that stresses are strains; but his first definition shows that stresses are not strains.

The author would be well advised to suppress this page (23) in future editions, lest the demerits of a page should mar the sale of what is otherwise a useful and commendable book.

Further Experiments with Eccentrically Loaded Reinforced Concrete Columns (Weitere Versuche mit exzentrisch belasteten Eisenbetonsäulen). By Dr. Maximilian Ritter von Thullie.

Leipzig and Vienna: Franz Deuticke, 1912. 8 Kr.

Prof. von Thullie and his staff have now completed a very extensive series of experiments with eccentrically loaded columns, the results of which are collected in the present volume. No less than 434

reinforced concrete columns, 12 cm. square and 1·5 or 1 metre long, were tested, in addition to the compression cubes. The ends of the columns were enlarged and strengthened with wire, in order that failure should as far as possible be limited to the middle portion. The linear deformation, and in some cases also the bending, was measured by means of mirror instruments. The principal conclusions reached are as follows :—

The influence of the height, within the limits mentioned, is inappreciable when the loading is central, but becomes marked under eccentric loading. The Austrian rules for computation are justified, but the allowance for buckling should be made according to the regulations of 1907, rather than the later rules of 1911.

Dr. von Emperger's conclusion, that the shell of concrete external to the longitudinal reinforcement does not share in the strength of the column, is not confirmed, and leads to impossible stresses. The results on the whole agree well with the ordinary assumption that the whole of the concrete shares equally in carrying the load.

The report is a valuable contribution to the experimental work on this subject, and represents a large amount of patient labour.

Booklets of the Associated Portland Cement Manufacturers (1900) Ltd.

Published at Portland House, Lloyd's Avenue, London, E.C.

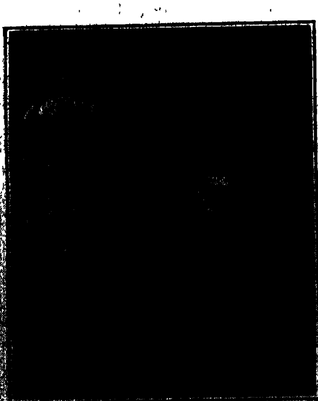
This company have recently published several new editions of their various pamphlets, and this gratuitous printed matter formed one of the features of their exhibit at the recent Building Trades Exhibition.

"Examination of Concrete Aggregates" sets out in a concise, practical, and clear manner various tests which can be applied on a job for testing the aggregates to be used for concrete, special care having been taken to avoid and eliminate elaborate and technical calculations. The booklet is illustrated showing the various appliances used for this work, and by permission of the company we reproduce their sketch of the apparatus used for determining whether concrete is mixed in specified proportions.

The literature further includes :—

"Cement Testing Apparatus," showing the various apparata, etc., used for this important investigation work.

Apparatus for Crushing Tests.
"Cement Testing Apparatus."

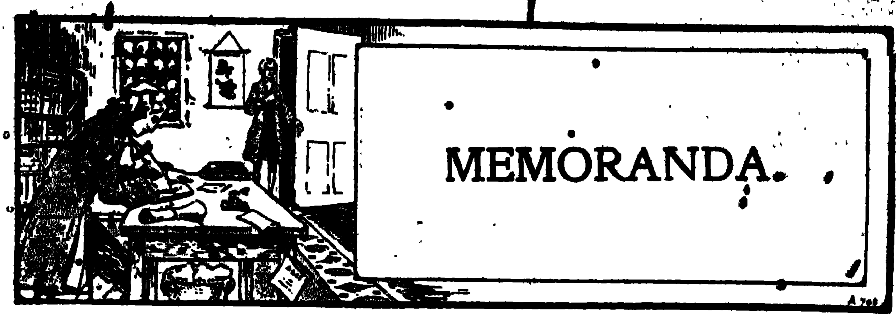


[illegible] of Concrete Aggregates."

"Portland Cement Memoranda" contains various extracts and tables which appear in the company's useful handbook, "Everyday Uses of Portland Cement," and which was fully dealt with by us in a former issue.

"Fictitious Portland Cement" sets out clearly the difference between "natural" cement and "Portland" cement, and warns users as to the dangers of the former. Special attention is called to the necessity of only employing a good artificial cement which will in every way comply with the requirements of the British Standard Specification.

"Reinforced Concrete Structures" gives many illustrations of buildings erected by the company in reinforced concrete.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Concrete Institute. Annual General Meeting.—The feature of the Annual General Meeting of the Concrete Institute was the presentation to Mr. Richard L. Humphrey, M.Inst.C.E., M.Am.Soc.C.E., of a medal in recognition of his excellent Paper on "Fireproofing." Mr. E. P. Wells, J.P., who presided, made some complimentary remarks as to Mr. Humphrey's useful work on the other side of the Atlantic, and Mr. Edwin O. Sachs, F.R.S.Ed., in accepting the medal on behalf of Mr. Humphrey, for transmission to the United States, dwelt on the important rôle that concrete was playing and would play in the future in the fire preventive schemes for fire preventive building construction at home and in the Colonies.

The Annual Meeting was followed in the evening by a very successful dinner at the Connaught Rooms, some 120 members and friends attending, and the arrangements were both interesting and pleasant. There was a considerable attendance of presidential officers from other technical societies, including the Architectural Association, the Society of Architects, the Districts Surveyors' Association, the Institution of Civil Engineers, and the Institution of Municipal Engineers, whose President was entrusted with the Toast of the evening, namely, "The Concrete Institute."

Other notable visitors present were Mr. W. E. Riley, F.R.I.B.A. (Superintending Architect, the London County Council), and Mr. H. Greville Montgomery (Building Trades Exhibition); whilst of the Institute's own officers who supported Mr. Wells, there were present of the Vice-Presidents Mr. H. Percy Boulnois, M.Inst.C.E., Mr. Edwin O. Sachs, F.R.S.Ed., and Mr. F. E. Wentworth-Sheilds, M.Inst.C.E., and of the Past-Presidents Sir Henry Tanner, C.B., I.S.O.

A new feature was the attendance of the Press at this dinner, and the four following were invited and represented, namely, *Engineering*, *The Builder*, the Central News Agency, and this Journal.

The International Road Congress.—The third International Road Congress takes place in London this month (June 23rd to 28th) under the auspices of the International Commission of Road Congresses. The Congress is representative in the truest sense of the term, nearly all the leading countries of the world having appointed delegates, and practically all the many associations, etc., directly or indirectly interested being represented on the Council. Questions of the greatest importance relating to this far-reaching subject in its manifold aspects will be discussed. We give a short summary of the Papers and Communications which will be brought forward.

Before giving this summary we feel it incumbent on us to make mention of the excellent organisation and arrangements for this great gathering. In addition to the meetings for the presentation of papers and discussions, many excursions have been arranged to different parts to enable members to study the various types of roads and highways of this country.

The following is a summary of the different papers to be presented:—

PAPERS.

Section I—Construction and Maintenance.—The questions to be discussed under this heading include:—"Planning of New Streets and Roads," "Types of Surfacing

to be Adopted on Bridges, Viaducts, etc.," "Construction of Macadamised Roads," "Wood Paving."

Section 2—Traffic and Administration.—Under this title we find papers on "The Methods of Lighting Public Highways and Vehicles," "Observations Noted Since 1908 as to the Various Causes of Wear and Deterioration of Roadways," "Regulations for Fast and Slow Traffic on Roads," "Authorities in Charge of the Construction and Maintenance of Roads, Functions of Central and Local Authorities," "Finance of the Construction and Upkeep of Roads."

COMMUNICATIONS.

Section 1—Construction and Maintenance.—We note that contributions will be made on "Tests of Materials," "Improvements Adapted Since the Second Congress in Machinery Used in the Construction and Maintenance of Macadamised Roads," "Constructions of Waterbound Macadamised Roads," "Technical and Economic Study of the Comparative Advantages of Different Types of Roads," "Various Types of Stone Paving in Use."

Section 2—Traffic and Administration.—Communications will be made on the "Qualifications of Engineers and Surveyors in Charge of the Construction and Maintenance of Roads," "Statistics of Cost of Construction and Maintenance," "Terminology Adopted or to be Adopted in Each Country Relating to Road Construction and Maintenance," and the "Development Since the Second Congress of Self-propelled Public Service Vehicles."

Full particulars of the Congress as to membership, etc., can be obtained from the Hon. Secretary, Mr. W. Rees Jeffreys, Road Congress Offices, Queen Anne's Chambers, 28, Broadway, Westminster, S.W.

Concrete for Repair Work.—Cement concrete was the agent employed for repairing a cracked cylinder casting in an American locomotive shop. According to the *Railway Gazette*, the engine came into the shop with a bad crack in the wall of the steam passage in the right-hand cylinder. The crack was high up on the contour of the wall and in such a position that it was impossible either to weld or patch it, and it was of sufficient size to lay the engine aside from actual work with the trains it was accustomed to haul. As an experiment it was decided to fill the cored cavity in the cylinder around the cracked wall with concrete, and in carrying this out a hole 2½ in. diameter was drilled in the front wall at the extreme top of the cavity. A wooden cover was fitted across the bottom of the cavity as high up as it could be inserted. A mixture of Portland cement and sand in equal proportions was made and worked into a liquid state so that it would run easily. About two wheel-barrow loads of this was inserted through the hole, nearly filling the cavity. It was allowed five days to stand and the engine then went into regular service. Nine months later, when the same locomotive came in for a general overhaul, the repair was examined and found to be in perfect condition, no leakage of any kind taking place. It was decided that it was unnecessary to renew the cylinder. The same method has been employed for carrying out similar repairs on another locomotive.—*Engineer*.

TRADE NOTICES.

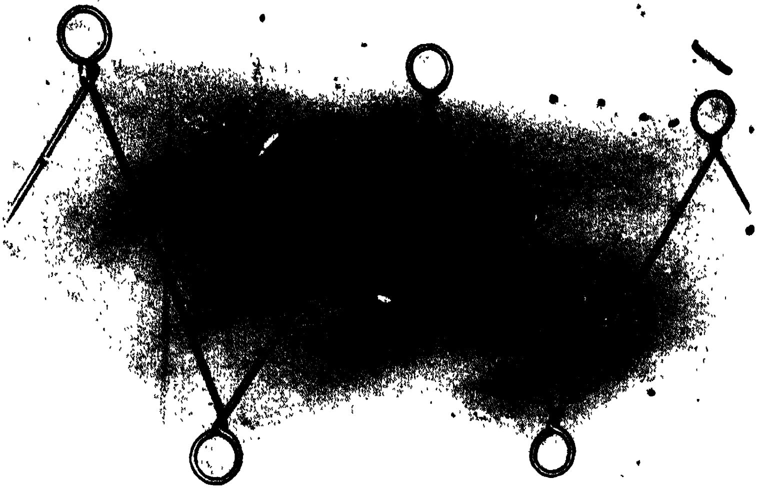
Naylor's System of Reinforcement.—Particulars have just reached us of a new system of reinforcement.

This system consists of a lattice bracing formed as shown in the accompanying illustration. The bracing, as will be seen, consists of a series of loops carried diagonally and made from one and the same rod, the loops varying from ⅛ in. to ⅜ in. in diameter. The loops and diagonals are continuous, and the loops slip over the top and bottom horizontal members of a beam or girder, or the vertical members of a column or pile.

It is claimed that by this means the various bars are fixed rigidly in relation to one another, and are bound absolutely in their proper place, and so are secured from any derangement or displacement, by the ramming and placing of the concrete in the forms once the reinforcement is attached to the horizontal or vertical members.

It is further stated that the system lends itself readily to reinforcement in the form of a rigid frame for any particular beam, column, girder, or pile, it being possible to make any number of these frames and fix them to any required spacing.

Briefly the advantages claimed for this system are: a continuous bond, the reinforcement is not displaced during construction, all stresses are provided for, no special or patent bars are required, and, finally, that it is economical. In the book we have before us various illustrations are given of the different ways in which the reinforcement



ment can be made for beams and girders, and special sections are devoted to beam and column construction. There are also illustrations of the application of the system to floor and bridge construction.

Full particulars can be obtained from Messrs. Naylor Bros., 23, Estate Buildings, Huddersfield.
